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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN NO. 64.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

CONTENTS AND INDEX.

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1911.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN NO. 64.
L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

I. THE MEXICAN CONCHUELA IN WESTERN TEXAS IN 1905.
By A. W. MORRILL, *Special Field Agent.*

II. NOTES ON THE ECONOMIC IMPORTANCE OF SOWBUGS.
By W. DWIGHT PIERCE, *Special Field Agent.*

III. NOTES ON "PUNKIES."
By F. C. PRATT, *Special Field Agent.*

IV. AN INJURIOUS NORTH AMERICAN SPECIES OF APION, WITH NOTES ON RELATED FORMS.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

V. INSECTS INJURIOUS TO THE LOCO WEEDS.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

VI. THE GREENHOUSE THRIPS.
By H. M. RUSSELL, *Agent and Expert.*

VII. NEW BREEDING RECORDS OF THE COFFEE-BEAN WEEVIL.
By E. S. TUCKER, *Special Field Agent.*

VIII. THE WOOLLY WHITE-FLY: A NEW ENEMY OF THE FLORIDA ORANGE.
By E. A. BACK, *Agent and Expert.*

IX. NOTES ON A COLORADO ANT.
By H. O. MARSH, *Agent and Expert.*

X. THE PECAN CIGAR CASE-BEARER.
By H. M. RUSSELL, *Agent and Expert.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF ENTOMOLOGY.

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D. M. Rogers, *in charge of preventing spread of moths, field work.*
Rolla P. Currie, *in charge of editorial work.*
Mabel Colcord, *librarian.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., November 30, 1910.

Sir: I have the honor to transmit herewith ten papers on miscellaneous insects for publication as Bulletin No. 64 and as No. IX of the series of bulletins entitled "Some Miscellaneous Results of the Work of the Bureau of Entomology." These papers, which were issued separately during 1907, 1908, 1909, and 1910, are as follows: The Mexican Conchuela in Western Texas in 1905, by A. W. Morrill; Notes on the Economic Importance of Sowbugs, by W. Dwight Pierce; Notes on "Punkies," by F. C. Pratt; An Injurious North American Species of Apion, with Notes on Related Forms, by F. H. Chittenden; Insects Injurious to the Loco Weeds, by F. H. Chittenden; The Greenhouse Thrips, by H. M. Russell; New Breeding Records of the Coffee-bean Weevil, by E. S. Tucker; The Woolly White-fly, by E. A. Back; Notes on a Colorado Ant, by H. O. Marsh; the Pecan Cigar Case-bearer, by H. M. Russell.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The present publication comprises ten articles previously published separately as parts and now brought together to form the complete bulletin, which is No. IX of the series entitled "Some Miscellaneous Results of the Work of the Bureau of Entomology." The previous bulletins of this series are Nos. 7, 10, 18, 22, 30, 38, 44, and 54. The articles of the present bulletin relate to species which, although economically important, do not properly come under the scope of any of the other bulletins thus far published in parts, viz, those relating to forest insects, the cotton boll weevil and related and associated insects, truck-crop insects, deciduous fruit insects, cereal and forage insects, and apiculture. The investigations the results of which are here published were, however, conducted coincidently with the various projects of several branches of the Bureau, including those dealing with some of the groups of insects mentioned above.

The first paper treats of the Mexican conchuela, a species investigated in Mexico in 1904, at which time it had not yet been reported to entomologists as of economic importance in the United States. It was predicted at that time that should the pest become abundant in Texas it would cause considerable damage to crops. The results of investigations in Texas in 1905 confirmed the prophecies of 1904.

Part II presents economic notes on three common species of sowbugs encountered during field-crop investigations in Texas and other parts of the South, while Part III, by F. C. Pratt, treats of the biologies of the various biting flies belonging to the genus Ceratopogon, known commonly as "punkies."

Part IV treats of a small weevil (*Apion griseum* Sm.) injurious to beans in Texas and New Mexico and includes biologic notes on a number of related forms.

Part V considers a number of the more important insects which feed upon the loco weeds. This investigation was undertaken in cooperation with the loco-weed investigations of the Bureau of Plant Industry, and as it was conclusively shown that insects of several species were largely responsible for control of the plant on prairies and grass lands a publication covering these insects was deemed desirable.

Part VI considers the greenhouse thrips (*Heliothrips hæmorrhoidalis* Bouché), a species previously recorded as injurious to a number of hothouse plants. This insect was found injuring mango, crotons, and other plants on beds and in parks at Miami, Fla. The results of a series of experiments for its control are given in this number.

Part VII is largely supplemental to an article in Bulletin No. 8 of the Division of Entomology, giving a note on new food materials for the coffee-bean weevil (*Araecerus fasciculatus* DeG.). This insect was discovered working in chinaberries and cornstalks adjacent to cotton fields during an investigation of cotton insects.

A new and dangerous species of Aleyrodes attacking citrus fruits is the subject of Part VIII. This species (*Aleyrodes howardi* Quaint.), which occurs on several islands of the West Indies, including Cuba and Porto Rico, has recently made its appearance in Florida. Present indications are that this species will be controllable by the same measures used for the citrus white fly, which it much resembles in capacity for damage.

Part IX gives the results of experiments undertaken for the control of a species of ant (*Formica cinereorufibarbis* Forel), which fosters the melon aphis in Colorado, protecting it largely from predaceous enemies. The control of this ant may prove of great value as a measure against the melon aphis.

Part X is a biologic account of a minor pecan pest, the pecan cigar casebearer in the South, and includes suggestions for its control.

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[a] The ten papers constituting this bulletin were issued in separate form on April 2, 1907 (Pts. I to III), January 14 and May 29, 1908 (Pts. IV and V), August 4 and 5, 1909 (Pts. VI and VII), and May 7, October 17, and November 12, 1910 (Pts. VIII to X).

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ERRATA.

Page 25, line 11 from bottom, for *C.* read *Ceratopogon.*
Page 41, line 9 from bottom, for *virginica* read *virginiana.*
Page 43, between lines 4 and 5 insert (*Heliothrips hæmorrhoidalis* Bouché).
Page 51, lines 10 and 17, for *azalia* read *azalea.*
Page 51, line 11, for *lauristina* read *laurestina.*
Page 51, line 17, for *catleyia* read *cattleya.*
Page 51, line 17, for *dendrobuim* read *dendrobium.*
Page 80, line 12, for *1893* read *1883.*

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part I.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE MEXICAN CONCHUELA IN WESTERN TEXAS IN 1905.

BY

A. W. MORRILL,

Special Field Agent.

ISSUED APRIL 2, 1907.

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U. S. D. A., B. E. Bull. 64, Part I. Issued April 2, 1907.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE MEXICAN CONCHUELA IN WESTERN TEXAS IN 1905.

(*Pentatoma ligata* Say.)[a]

By A. W. Morrill,
Special Field Agent.

INTRODUCTION.

In a recent bulletin of the Bureau of Entomology [b] the writer gave an account of the Mexican conchuela (*Pentatoma ligata* Say, fig. 1), based upon an investigation conducted in northern Mexico in September, 1904. It was predicted that should the pest ever become very abundant in this country, where more diversified farming is usually practiced, it would be likely to affect a wide range of farm crops instead of confining its attacks to cotton alone. Almost unknown in 1903, the conchuela, as it is called by the natives of Mexico, first became of considerable importance as a cotton pest in the leading cotton district of Mexico—the "Laguna"—and in 1904 established its reputation as an enemy of alfalfa in western Texas by ruining in specific instances seed valued at over $1,000, representing the loss to the crops of two growers from whom definite reports were obtained. This loss in western Texas was, however, first made known to entomologists in July of the following year (1905), through correspondence of a resident of Barstow, Tex., with Mr. W. D. Hunter, in charge of the investigations on cotton insects conducted by this Bureau. As the writer was at that time in Mexico, continuing his investigations of this pest, Mr. J. C. Crawford was sent to Barstow to investigate the economic status of the insect there. His preliminary observations were made on July 20 to 22, inclusive, and were followed by visits to Barstow by the writer on August 11 and 12 and September 12, and by Mr. Crawford on October 13 and November 14. The reports of Mr. Crawford, which were duly submitted to Mr. Hunter, have been freely used by the writer in preparing this paper.

[a] Order Hemiptera, family Pentatomidæ.

[b] Bul. 54, Bur. Ent., U. S. Dept. Agric., pp. 18–34, 1905.

AN ASSOCIATED SPECIES.

An allied pentatomid, the grain bug[a] (*Pentatoma sayi* Stål), was found at Barstow associated with the conchuela. In 1905 this species was not plentiful enough to cause much damage to crops by itself, but as the character of its injury and that of the conchuela is the same it is necessary to consider the two species together when they are found on the same food plant. In this case they were found together only on alfalfa and Milo maize, although the grain bug is known to have a wide range of food plants and probably is fully as general in its feeding habits as is the conchuela. The history of the former species as a pest antedates, even in western Texas, that of the latter, for as long ago as December, 1895, specimens of *Pentatoma sayi* were received by this Bureau from Toyahvale, Reeves County, Tex., with a report that they had destroyed 40 acres of peas and 2 acres of lima beans on the correspondent's farm. It is interesting to note that this report came from a point not 50 miles from Barstow. Since that time this species has earned a bad reputation by its destructiveness to wheat and oats in Colorado and elsewhere.

GENERAL AGRICULTURAL CONDITIONS AT BARSTOW, TEX.

Ward County, of which Barstow is the county seat, is situated in western Texas, a short distance south of the southeastern corner of New Mexico. With the exception of a narrow valley along the river the country consists of high rolling prairie covered in large part with a short growth of mesquite and sage. Being in the arid region the rainfall is too light to be depended on for agricultural purposes and all crops are grown under irrigation, a practice which began with the settlement of the county in 1891. Water for irrigation is obtained from the Pecos River, and at present about 10,000 acres are under cultivation in the county. Of this area, in 1905, about 5,000 acres were devoted to cotton and the greater part of the remainder to grapes, peaches, and alfalfa. The elevation of Barstow is about 2,500 feet above the sea level.

DAMAGE TO CROPS PREVIOUS TO 1905.

According to residents of Barstow who are best informed concerning the conchuela, the insect never, previous to 1904, attacked crops of any kind in sufficient numbers to attract attention. As far as can be learned there had been, previous to that time, no attempt to produce a seed crop of alfalfa. The occurrence of this pest on cotton in moderate numbers is not likely to be associated with the

[a] In using this common name for this species the writer follows Prof. C. P. Gillette. Bul. 94, Colo. Exp. Sta., p. 3, Dec., 1904.

injury which usually first becomes apparent upon the opening of the bolls. The most notable losses in 1904, which with little doubt were due to the conchuela, were on the farms of Mr. C. E. Pierce and Miller Brothers. The former had 120 acres of alfalfa which was cut for the seed crop about the middle of July, from 150 to 200 pounds of seed per acre being expected. It was noticed that this insect was very abundant in the field, but the extent of the damage was fully realized only when an average of 83⅓ pounds of seed per acre was obtained. At the prevailing value of 12 cents per pound the estimated loss was from $8 to $14 per acre, or from $960 to $1,680 for the entire field. The 10 acres of alfalfa belonging to Miller Brothers should have produced at least 150 pounds of seed per acre, according to general estimates, but so much of the seed was ruined, supposedly by the conchuela, that the yield was reduced to 60 pounds per acre. The average loss per acre was estimated as at least $10. Other losses of this kind occurred in Ward County during 1904, but the information obtainable concerning them is less definite. According to one report, alfalfa growers at two other points in the Pecos River Valley—Grand Falls and Toyah Creek—experienced a failure with a seed crop of alfalfa in that year which they attributed to "weevil," a term commonly applied to the cause of such losses even before an insect has been located upon which to place the responsibility. In this case the writer believes that at least the greater part of the losses in question can be safely considered as due to the work of *Pentatoma ligata*, together with the grain bug, *P. sayi*.

CROPS DAMAGED IN 1905.

ALFALFA.

Direct observations, both in western Texas and northern Mexico, showed that fields devoted to alfalfa are capable of harboring the conchuela in enormous numbers. In the Laguna district in Mexico alfalfa has been grown for several years, but only for hay and forage, and in comparatively small quantities on the cotton plantations. As far as could be learned, previous to 1905 the pest here considered never attracted attention on account of its occurrence in the alfalfa fields, but in that year it became so abundant that at Tlahualilo, State of Durango, upon the cutting of a crop, adjacent cotton fields and a small vineyard were overrun by myriads of the insects, while several miles distant at another plantation it was first brought to the notice of the managers by appearing in large numbers in the troughs in which green alfalfa was fed to stock. In these cases, no seed crop being grown, the attack was limited to the leaves and stems. The effect of the extensive feeding on these parts can not be definitely

stated, as in all cases where plants without seed were heavily infested the cutting was made before the writer had an opportunity to make an examination. According to report, however, no marked effect upon the plant was produced in the instances here recorded, and, accordingly, until more is known, we may assume that where it is not intended to produce seed the principal danger incident to the occurrence of the conchuela in alfalfa fields lies in the fact that a choice breeding place is furnished the insects, which may multiply to enormous numbers and spread to other crops. This phase of the subject will be discussed elsewhere in this paper and also in a report on Heteroptera attacking the cotton plant.

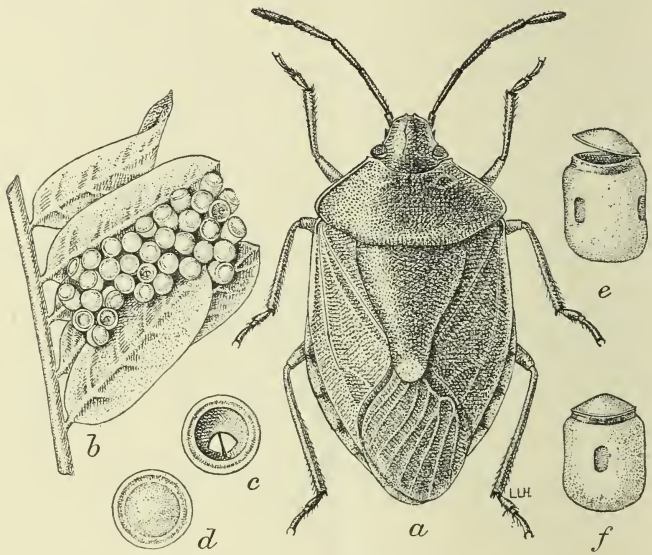

FIG. 1.—The conchuela (*Pentatoma ligata*): *a*, adult bug; *b*, egg mass on leaves; *c*, egg after hatching, lid removed showing egg burster; *d*, egg before hatching, from above; *e*, egg from side, showing lid above exit hole; *f*, egg before hatching, from side; *a*, enlarged 4 diam.; *b*, enlarged $2\frac{2}{3}$ diam.; *c-f*, enlarged 9 diam. (Author's illustration.)

In infested fields when the seed is present the bugs may be seen clinging to the seed clusters extracting the rich juices by means of their thread-like setæ. The seed pod, when once fed upon, shrivels and turns dark and is readily distinguished from uninjured seed pods. No attempt has been made to determine how rapidly a bug progresses with its destructive feeding, but as these insects are usually observed to be engaged in this way as long as desirable food remains, and as the individual seed is small, undoubtedly each one of the insects is capable of destroying a very large number of the seed pods during its existence.

Cutting of the alfalfa checks the multiplication of the pest, but also has the effect of driving the bugs elsewhere in search of food,

often with more or less serious results to neighboring crops. It should also be noted that the longer time required to produce a seed crop is favorable to the production of large numbers of the insects. Windrows of alfalfa hay, originally intended for thrashing for the seed, in the field of Mr. Carson, at Barstow, were found to harbor many adult conchuelas which were for the most part busily engaged in destroying the last few seed clusters. It would thus appear that the danger is not over with the cutting of the alfalfa, and that thrashing should be attended to as soon as possible if the insects are present and injury is to be avoided.

The only extensive damage to alfalfa by this insect at Barstow during 1905 was on the farm of Mr. J. P. Carson. Other growers, owing to their experience of the previous year, decided to grow no seed crop; thus indirectly many suffered a loss which should be charged up to the insect, as an average crop of seed has a value equal to several times that of a single cutting for hay. Mr. Carson had 55 acres ready for cutting for the seed the last week in July, but the damage by the bugs amounted to complete destruction, for although the land was originally heavily seeded, there was not sufficient uninjured seed to defray the expense of thrashing. The loss was considerably more than $1,500, in addition to the partial loss of a hay crop in the extra time allowed for the maturity of the seed.

Miller Brothers in 1905 fortunately avoided the destructive work of the insects and made a fair seed crop. At Barstow the interval between cuttings for hay is on the average about four and one-half weeks, while for the maturity of the seed an additional period of about three and one-half weeks is necessary. Other farm work prevented Miller Brothers from cutting their alfalfa when it was in prime condition for cutting for hay. As the seed began to mature, the scarcity of the pest which had proven so destructive the previous season caused the owners to anticipate a successful seed crop. On September 13 the writer, who made a careful examination of the condition of the alfalfa field referred to, found the bugs scarce, as reported, and the damage to the seed, which was already mature, very slight. The yield of seed reported by Miller Brothers for the 10 acres was 1,499 pounds.

MILO MAIZE.

On August 11 a field of Milo maize was examined at Barstow, and it was found that in certain spots a considerable proportion of the seed was ruined, while more or less ruined seed could be found throughout the field. According to the owner, Mr. Carson, the conchuelas had been very abundant a week previous, as many as 25 of the insects frequently being noted on a single seed head. They were found to be generally distributed throughout the field on August 11,

but in small numbers, the largest number found on a single seed head being five—two adults, two fourth-instar nymphs, and one fifth-instar nymph. On the Milo maize, as on the alfalfa, *Pentatoma ligata* was accompanied by *P. sayi*, but in more nearly equal numbers; this is not necessarily of any special significance, though possibly it may indicate a preference of the latter species for the seed of the grains.

COTTON.

The first examination for the conchuela in the cotton fields at Barstow was on August 11, when of the five fields visited specimens of the insect were found in all except one. In every case the number of damaged bolls, although in small proportion, gave evidence of the occurrence of the insect in somewhat larger numbers some weeks previous. In one field an examination of 100 plants showed an infestation of 5 per cent of the plants, with 12 adults per 100 plants. The damage to the bolls in this field amounted approximately to 15 per cent. Another field of about 10 acres was found to be damaged to a less extent except for about one-half an acre near one side where, of 60 bolls selected at random, 30 per cent were destroyed by bugs. The writer estimates, as a result of personal examinations in many fields at and near Barstow, that the average damage to cotton by the conchuela in 1905 was about 10 per cent.

PEACHES.

Although peaches have been grown at Barstow for several years we have no report of damage to the fruit by the conchuela or other bugs until 1905, when the matter was reported by Mr. C. E. Pierce and investigated, as stated in the introduction, by Mr. Crawford and the writer. The attack was confined to the fruit of the earliest varieties in their first fruiting season. The trees were located on the side of the orchard adjacent to the 120-acre alfalfa field, the damage to the seed crop of which in the previous year has already been mentioned. Shortly after the 10th of July, coincident with the cutting of the alfalfa, the bugs were noticed on the fruit of these trees, which was just beginning to ripen. The trees soon became very heavily infested, and on July 20 it was not uncommon to observe from 10 to 15 on a single peach and in one instance 20 were counted. The tendency of the conchuelas to congregate on certain individual peaches was very marked, as has likewise been observed in their occurrence upon cotton bolls.[a] On the most heavily infested trees, owing to this habit, many peaches at any given time seemed neglected, but all on the attacked trees were ultimately destroyed. The injured fruit became shrunken in spots and sponge-like to the touch, finally

[a] Bul. 54, Bur. Ent., U. S. Dept. Agric., p. 26, 1905.

falling to the ground. It was apprehended that the pests would transfer their attention to the late peaches when these began to ripen, and a few were observed to do so, but apparently when the supply of early peaches was exhausted or rendered unfit for further feeding, the late peaches were not mature enough to be attractive, and consequently suffered practically no injury from this source.

GRAPES.

In 1905 at Barstow the fruit in the vineyards was in general only slightly affected by *Pentatoma ligata*. The principal damage was in the small gardens in town, where in certain instances the destruction was practically complete. Probably owing to the large area occupied by the vineyards and to the fact that the fruit of the different varieties ripens at about the same time, no especial concentration of the insects in the large vineyards was noticed, and there was no indication that any such concentration occurred. The ripe fruit is preferred, although when the food supply is short it may be attacked when immature. The injured berry shrivels and under the influence of the hot sun soon becomes raisin-like.

At Tlahualilo, Durango, Mexico, on July 17, 1905, a vineyard of about 10 acres with vines heavily loaded with fruit became thoroughly infested by direct migration from an adjacent alfalfa field of adults and of nymphs in the last two instars. Each cluster of grapes was attacked by several bugs, the maximum noted on a single cluster being 25. Without consultation with the writer the grapes were picked immediately upon discovery of the infestation, the presumption being that the removal of their food would serve as a check to the insects, to the benefit of the cotton fields. This step was, however, inadvisable, since the fruit, which was of comparatively small value, would have served as a trap at which the bugs could have been easily destroyed when so thickly congregated. As it was, the bugs gathered in groups of hundreds on the trellis posts and on the vines, principally at the forks, where they were destroyed, partly by spraying and partly by use of a gasoline-blast torch. The last-mentioned method, while effective in its destruction of the pest, injured the vines to a certain extent in nearly all cases.

GARDEN VEGETABLES.

Between the middle of July and the middle of August garden crops at Barstow were affected to a considerable extent by this destructive pest. Owing to the comparatively small amount of land devoted to such crops, the actual money equivalent of the loss was not great. The crops which suffered most were peas, beans, and tomatoes. In each case the attack was restricted almost entirely to

the seed or fruit, thus accomplishing a maximum of damage. Under another heading the writer has referred to the destruction of peas and beans in Western Texas, not far from Barstow, by the grain bug. Among other cases on record which give further evidence of the losses pentatomid bugs may cause by their attacks on vegetables is one quoted by H. G. Hubbard[a] from the report of a Florida correspondent on his experience with a species commonly called the green tree bug (*Nezara hilaris* Say). According to the report, this species attacked cowpea vines before any seed was developed and completely ruined 35 acres of this crop, so that no good seed was obtained. A garden crop of tomatoes was also reported to have been entirely destroyed, the ground under the vines being almost covered by the fallen fruit. The injured fruit was described as reddish-yellow in color at the point punctured, and when cut was found to be "full of lumps and totally devoid of flavor." These records of the damage by other pentatomid bugs to general garden crops show the extent to which the conchuela is capable of affecting these crops when they are grown on a more extensive scale than was the case at Barstow at the time the observations recorded in this paper were made.

OTHER FOOD PLANTS.

The principal natural food plants of the conchuela are the mesquite and related leguminous plants, the beans being the object of attack. It would require more than one season's observations to determine how important is the connection between the abundance of mesquite beans and the abundance of the insects on cultivated plants. It is presumable that during the period when the insects are multiplying most rapidly the abundance of rich food such as the mesquite bean provides is an important factor in determining the amount of subsequent injury to crops. At Barstow, in addition to the mesquite and the crops which have been separately discussed, the conchuela has been found feeding on the fruit of peppers, on squash vines, and on the leaves of yucca. It has also been reported on good authority to have been observed in considerable numbers on corn, and the writer has in Mexico found egg batches of this species attached to the green leaves of corn. In general, the species may be said to be almost omnivorous, showing a preference, however, for fruits and seeds.

SEASONAL HISTORY.

The multiplication of the conchuela in western Texas seems to follow the same course as has been observed in northern Mexico; in other words, the maximum number is reached between the middle and

[a] Report on Insects Affecting the Orange. Div. Ent., U. S. Dept. Agric., p. 160, 1885.

last of July, after which the number diminishes rapidly. The bugs are strong fliers, which accounts for their sudden appearance on a given crop, and in some cases for their sudden disappearence from it.

On July 20–22 no eggs or young could be found on the infested peach trees, nor could any of these stages be found on August 11 and 12 after the adults had entirely disappeared from the trees. If any eggs were deposited by the bugs when the latter were attacking the peaches the resulting nymphs were probably carried to the ground with the falling of the fruit, for the interval between the examinations was not sufficiently long for them to have reached the winged or adult stage. The only breeding places of consequence found at Barstow were in the alfalfa fields. Here eggs and nymphs were found in large numbers on August 11 and 12. A month later the insects had been reduced by at least one-half, and their scarcity was noticeable everywhere except in small areas in some fields of alfalfa and along the borders near fences and ditches where the cuttings had not been made at regular intervals. Of 32 adult pentatomids collected in the alfalfa fields September 12, 26 were *P. ligata* and 6 *P. sayi*. At the next examination, on October 13, it was evident that the insects were still decreasing in numbers, but the nymphs in the last two stages were proportionally more abundant than before. In the lot of 16 adults and 49 nymphs collected at that time, *P. sayi* was not represented. The last examination, made on November 14, showed that the conchuelas had almost entirely disappeared; a half hour's search where, at the time of previous examinations, they had been found most abundant, resulted in the capture of only 6 adults, no nymphs being seen.

NATURAL ENEMIES.

EGG PARASITES.

Minute egg parasites belonging to the family Proctotrypidæ are generally known among entomologists to play an important rôle in checking the multiplication of many insects, so that anything which affects the numbers of these parasites frequently results in a corresponding benefit or injury to the crops attacked by the host insects. If these parasites of the eggs of pentatomids were eliminated, many of the pentatomids would undoubtedly be ranked among our most important insect pests. The importance of these parasites in checking the multiplication of the conchuela at Barstow in 1905 can be best emphasized by summarizing the results obtained by rearing parasites from eggs collected at that place.

Summary of results obtained by rearing parasites from eggs of Pentatoma ligata collected at Barstow, Tex., in 1905.

When collected.	Number of egg batches.	Total number of eggs.	Number of eggs hatched.	Per cent hatched.	Number of parasites emerged.	Per cent producing parasites.	Number of eggs destroyed by other agencies.	Per cent failing to produce nymphs.
August 11–12.....	6	181	35	19	41	22	0	81
September 12.....	13	246	20	8	148	54	[a]35	92
Total.....	19.	427	55	13	189	44	35	87

[a] Representing two batches of 13 and 22 eggs, respectively. Presumably destroyed by ants, the broken eggshells remaining.

Shrinking of the eggs, indicating infertility, occurred in no case among the eggs included above. From the fact that adult parasites frequently fail to emerge from the egg of the host even after

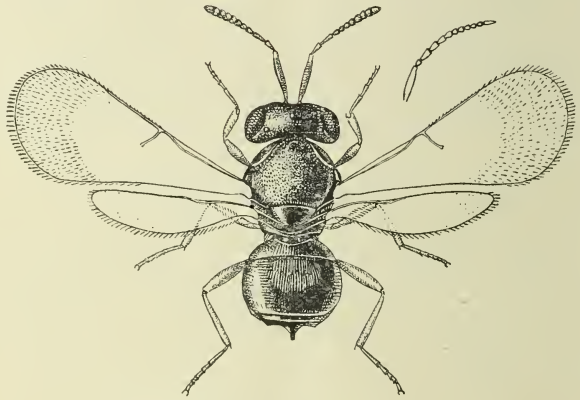

FIG. 2.—*Telenomus ashmeadi*, an important egg parasite of *Pentatoma ligata:* Adult female and antenna of male. Highly magnified (original).

breaking through the shell—and as far as observed it seldom occurs in nature that eggs of the conchuela fail to hatch when not destroyed by outside agencies—it may be concluded that practically all the eggs appearing intact which failed to hatch were destroyed by the parasites. In support of this supposition 10 eggs which neither hatched nor from which live parasites emerged, selected at random from the 19 batches above mentioned, were opened and each was found to contain a dead adult parasite. The specimens bred from the eggs of *P. ligata* and also of *P. sayi* from Barstow were all of the same species and identified by Dr. William H. Ashmead, of the U. S. National Museum, as a new species of the genus Telenomus (fig. 2). The writer will describe the species under the name *Telenomus ashmeadi*. An egg batch of the conchuela containing hatched and unhatched eggs is shown in Plate I, figure 1, and a parasitized egg batch in Plate I, figure 2.

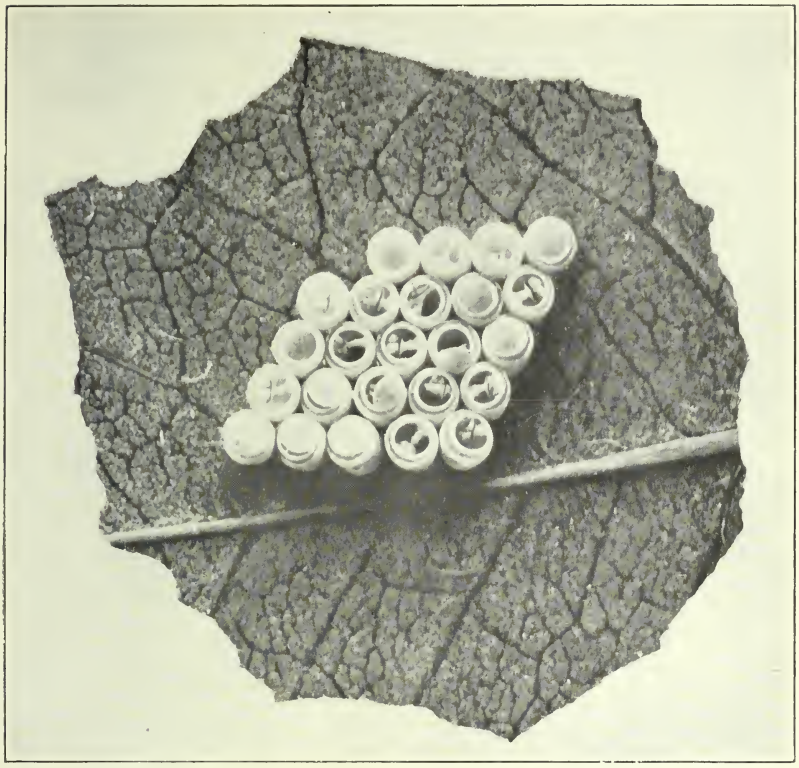

FIG. 1.—EGG BATCH OF CONCHUELA (PENTATOMA LIGATA), SHOWING HATCHED AND UNHATCHED EGGS. ENLARGED 6⅔ DIAMETERS (ORIGINAL).

FIG. 2.—EGG BATCH OF CONCHUELA (PENTATOMA LIGATA) FROM WHICH 32 PROCTOTRYPID PARASITES (TELENOMUS ASHMEADI) HAVE EMERGED. ENLARGED 6⅔ DIAMETERS (ORIGINAL).

The illustration shows three parasites, including male and female, ready to emerge; also an egg destroyed, probably by an ant.

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TACHINID PARASITES.

A species of the very useful family Tachinidæ, *Gymnosoma fuliginosa* Desv., has been reared from adults of the conchuela. The victims of this parasitic fly are distinguished by the yellowish-white egg or eggshell which remains attached to the thorax of the host unless it happened to have been attached to a nymph in the fifth instar, which afterwards molted. On August 11 and 12 only three parasitized specimens were discovered, two in the fifth nymphal instar and one an adult. An adult of this species of Tachinidæ was bred from one of these bugs. On September 12 parasitism by these tachinids was found to be more common than at the time of the previous visit. Of 24 adults examined at that time, 4 were found to be parasitized. On October 13, of 18 adults and 31 nymphs in the fifth nymphal instar, 2 only had been parasitized, both nymphs. While these parasites are decidedly beneficial and may be more useful under some conditions, they were not sufficiently abundant at Barstow in 1905 to explain the rapid decimation of the numbers of the conchuela which has been described under the subject of seasonal history.

PREDACEOUS ENEMIES.

Although no observations on the subject of predaceous enemies were made at Barstow, it seems important to refer briefly to the records of observations by others along this line, in order that it be not inferred that because pentatomids in general are characterized by their ability to produce an offensive odor they are immune to the attacks of insectivorous birds and of toads. On the contrary the crow[a] is believed to be especially fond of bugs of this group, and many other birds,[b] as well as the common toads,[c] seem to find them unobjectionable as food. If we accept the evidence of definite reports and observations during three successive seasons as indicative of the usual seasonal history of the conchuela, the period of maximum abundance is followed closely by a marked reduction in the numbers of the pest. In this it is not unlikely that birds will prove to be an important if not the leading factor.

METHODS OF CONTROL.

Under some conditions farm practices, such as the destruction of weeds in the fall and otherwise hindering the sucessful hibernation of the conchuelas, would be of unquestioned value in control, but under

[a] Bul. 6, Div. Orn. and Mam., U. S. Dept. Agric., p. 63.

[b] Buls. 13, Biol. Surv., Dept. Agric., U. S., pp. 25, 62, 70; 15, p. 23; 21, p. 43; 23, p. 26. Yearbook U. S. Dept. Agric. for 1895, pp. 417, 423, 429; Yearbook U. S. Dept. Agric. for 1900, p. 414, Plates L, LI.

[c] Bul. 46, Hatch (Mass.) Exp. Sta., p. 26. Bul. 91, Ky. Exp. Sta., pp. 62, 64.

the conditions in western Texas, such as those obtaining at Barstow, probably little good could be accomplished by such measures. With the mesquite-covered surrounding districts as a stronghold these insects probably will become established in the alfalfa fields each year and become more or less numerous as the season progresses, their numbers being governed by conditions which for the most part exert their influence secondarily through the natural enemies of the species. The question of control at Barstow, and where similar conditions prevail, resolves itself into: First, avoidance of damage to the seed crop of alfalfa; second, methods tending to prevent the insect's spread from alfalfa to other crops, or otherwise preventing infestations; third, direct remedies applicable for use when crops other than alfalfa become infested.

AVOIDANCE OF INJURY TO THE SEED CROP OF ALFALFA.

At Barstow the experience of alfalfa growers for two successive seasons, supported by direct observation by Mr. Crawford and the writer at regular intervals during 1905, has shown that the conchuelas are so numerous during July and August that an attempt to produce a seed crop during this period would be inadvisable. In northern Mexico observations extending over three seasons have shown the insects both to reach a maximum in numbers and to show a marked decrease therefrom during the last two weeks of July. This corresponded with the history of the pest at Barstow, and it is believed that the danger limits above given are sufficiently wide to cover all but exceptional cases under the present conditions. If a crop intended for seed promised to mature before July 1, probably but little damage would be accomplished by the conchuela, but this is entirely a surmise which it is hoped will be thoroughly tested when an opportunity presents itself. The same probabilities hold for a crop of seed which would mature after the 1st of September. This, moreover, has been substantiated by the experience of Miller Brothers at Barstow, which has been described under the subject of damage to alfalfa in 1905. Avoidance of the injury as here outlined is undoubtedly simpler than actually defending the seed in the field from attack.

A SUGGESTION AS TO MECHANICAL CONTRIVANCES FOR COLLECTING THE INSECTS.

Between the conchuela (*P. ligata*) and its near relative, the grain bug (*P. sayi*), whose reputation as a pest has already been mentioned, it may be anticipated here that in the course of time remedies will be demanded for use against such insect enemies of alfalfa in other sections of the country. In a field with ripening seed an experiment with an insect-collecting net in one hand and a stick in the other, simulating the action of an imaginary specially constructed

hopperdozer with a revolving fan, convinced the writer of the practicability of collecting these insects mechanically. The great majority of the insects, when undisturbed, may be found near the tops of the plants, on the seed clusters when these are present. They drop to the ground when slightly disturbed, much more readily, in fact, than when they have a footing on a more substantial object like a cotton boll. It is safe to predict that a contrivance for collecting will be devised when the necessity arises. It should be light, operated from behind, and consist essentially of an elongate metallic pan suspended below a revolving fan geared to the supporting wheels.

PREVENTIVE AND PROTECTIVE MEASURES.

If, as advised in one of the preceding paragraphs, no attempt is made to produce a seed crop during the period of the year when the conchuelas are dangerously abundant, an important factor in their multiplication and spread will be eliminated. But the shorter period required for the hay crop is sufficient to permit the insects to reach the enormous numbers indicated in the writer's reference to the occurrence on alfalfa in northern Mexico in 1905. Uusually the greater number of the insects will not reach maturity during the interim between cuttings, and the work of preventing the spread will be in part the checking of the migration of the crawling nymphs. This can be readily accomplished when necessary by leaving an uncut border around the field, where the insects when trapped can be destroyed by spraying with kerosene emulsion. As the insects show a marked tendency to concentrate in certain limited areas rather than to spread evenly over the fields, this can be taken advantage of by making a general examination of the field, before cutting, to locate the colonies. A few small boys in a few hours might pick up several quarts[a] of the adults when these are abundant and well concentrated. If this is not feasible, small heavily infested areas may be treated with kerosene emulsion, although adult pentatomids are apt to be quite resistant to this insecticide. At Tlahualilo, Durango, Mexico, on July 11, 1905, after the alfalfa hay had been made and stacked, countless hosts of the insects still remained in the alfalfa field in spite of the extensive migration to neighboring crops. Those that remained were largely concentrated near one corner of the field and, as suitable spraying apparatus was not available, destruction of the pest was accomplished by respreading about 3 or 4 tons of alfalfa hay over the ground and then burning it. This operation for the protection of the surrounding cotton fields against further invasion from this source was effective, but would be unnecessarily costly under ordinary

[a] One quart contains approximately 1,500 adult specimens of *P. ligata*.

circumstances. In the case of the chinch bug a practice of destruction by burning similar to the one here mentioned has been recommended for use under certain conditions.[a] Cooperation among the owners of adjoining farms is necessary in order to obtain the best results in the attempt to check the spread of the conchuela, as well as in the case of the chinch bug and many other insects.

A protective measure which may in some cases be recommended, especially for use in small gardens, consists in screening such crops as tomatoes with a cheap quality of mosquito netting.

REMEDIES WHEN CROPS OTHER THAN ALFALFA ARE ATTACKED.

The subject of remedies for use in protecting cotton against damage by the conchuela and related pests will be reserved for a future publication. When this insect attacks the seed of Milo maize and related grains little can be done except when the bugs are concentrated in large numbers in limited areas; then hand collecting or jarring from the plants may be advisable, particularly as a protective measure when such an infestation is an element of danger to neighboring crops. For remedial measures against the insect when it attacks garden vegetables and grapes we can suggest spraying with kerosene emulsion and collecting by hand, or, if it is necessary to carry on operations on a large scale, the bugs may be jarred into convenient receptacles containing kerosene and water, so arranged that they can be dragged between the rows if desired.

When attacking peaches a certain proportion of the bugs can be jarred from the fruit and killed on the ground, but this is at the best far from satisfactory, as the fruit itself is likely to be shaken off or otherwise injured and many of the bugs will escape by flying. Peach trees when pruned in accordance with the practice of the leading growers are low enough to permit hand picking of all the fruit and are correspondingly easy of fumigation. A light tent made of ordinary cotton sheeting can be placed over an infested tree by the use of poles and held in place at the bottom by dirt or stones. The burning of tobacco stems, pyrethrum, or buhach powder inside the tent will soon stupefy the insects and cause them to fall to the ground, where they can be easily and quickly killed. The fumes can be prevented from escaping too readily through the cloth by lightly painting it with linseed oil thinned with turpentine. This method of fumigation is inexpensive and has the further advantage of requiring but a few minutes' work for each tree.

[a] Bul. 17, old series, Div. Ent., U. S. Dept. Agric., p. 37, 1888.

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BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part II.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON THE ECONOMIC IMPORTANCE OF SOWBUGS.

BY

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Special Field Agent.

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NOTES ON THE ECONOMIC IMPORTANCE OF SOWBUGS.

By W. Dwight Pierce,
Special Field Agent.

Having been detailed to investigate certain injuries attributed to sowbugs, the writer presents the following notes concerning the life history and habits of three species of these isopods, namely, *Armadillidium vulgare* Latr., *Porcellio lævis* Latr., and *Metoponorthus pruinosus* Brandt. The first species, at least, is capable of doing considerable injury to garden crops, flower gardens, vines, and field crops in the vicinity of buildings, although it is also found to be a valuable scavenger. The scavenger habit, however, makes it an undesirable intruder in the house owing to the possibility that it may convey disease.

ARMADILLIDIUM VULGARE Latr.

The sowbug *Armadillidium vulgare* Latr. is commonly known as the "pill-bug," on account of its habit of rolling into a ball whenever disturbed. Ordinarily it is found only in the vicinity of habitations, in dark, damp places, such as woodsheds and cellars, under boards and rubbish, and around wells, cisterns, and water barrels. The open foundations under houses in the South give very favorable locations for breeding.

For several years the Department of Agriculture has received reports of injury from sowbugs to one or another crop in various parts of Texas. The sowbugs seem to have been on the increase from year to year. In 1905 the spring rains, although at times occasioning a natural check to these pests, brought about a series of conditions favorable to a rapid increase in their numbers. Moisture is a requisite to their life, and it also seems that vegetation is a standard article of food. The bad conditions of the ground throughout Texas during that year made all crops very late, so that by the time the succulent cotton and garden crops were coming up the new broods of young sowbugs were everywhere engaged in finding delicate, tender food.

At Dallas the cotton patch of the boll-weevil laboratory furnished ample evidence of the capacity of these crustaceans in devouring vegetation (see Pl. II). By April 14 the cotton was sending up the second, and in some cases the third, pair of leaves. At this time Mr. Springer Goes noticed that the growing tips in rows adjacent to buildings were badly eaten, although the injury extended over the entire patch to a greater or less degree. All plants which were tipped died very shortly, with the result that seven rows had to be entirely replanted. A great many of the seedlings of the second planting also were killed. Many gardens had suffered through attacks on the young sprouts of beans, peas, and tomatoes, and on rose bushes and other cultivated flowers. In December Mr. R. C. Howell found the sowbugs doing serious damage to roots of palmetto, one large plant being entirely killed. From Austin there came a note published in Farm and Ranch, dated April 29, 1905, which enumerated the following plants as subject to the attacks of this species: Butter beans, radishes, lettuce, mustard, potted plants, and also flower seed. The earlier planting of beans was untouched, while the late planting, owing to the favorable conditions for multiplication afforded the sowbugs, was seriously injured.

From economic literature the writer finds the following records of injury attributed to this species:

Miss Richardson[a] cites injuries to cucumbers and hothouse vegetables at New Orleans, La., to various plants at Fort Worth, Tex., and to date palms from Algeria, located at Washington, and states that these sowbugs are a most serious pest on mushrooms at Berkley, Va.

Mr. H. Garman[b] cites this species as very injurious to young cucumbers and lettuce in greenhouses, and recommends carbon bisulphid as a remedy.

With this information in hand, a series of seventy-five experiments was conducted in the laboratory in order to compare various conditions and foods in their effects upon this species. Over 900 individuals were involved in the experiments, of which the results may be here summarized.

The most favorable condition under which to keep the sowbugs was found to consist of a mixture of gumbo and sand kept moist, and a supply of fresh cotton leaves, leaving some old ones to decay and mold. Moisture is absolutely essential. With such conditions, sowbugs were carried through the entire period of the investigation, e. g., 10 females and 1 male were kept alive eighty days, and 4 of these

[a] Monograph on the Isopods of North America. By Harriet Richardson. Bul. 54, U. S. Nat. Mus., 1905.

[b] Bul. 91, Ky. Agric. Exp. Sta., 1901.

WORK OF ARMADILLIDIUM VULGARE ON COTTON.

[This shows the center of the injured area, which was replanted, and also the source of the infestation—the sheds. (Original.)]

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females were still alive one hundred and sixty days after the beginning of the experiment. The cotton leaves, when tender, were eagerly eaten.

Fungous growth was favorable only under certain conditions. In the experiments cited above the leaves in contact with the earth decayed and accumulated a rich growth of mold. Upon these decayed leaves the sowbugs seemed to thrive, although there was always evidence of feeding on green leaves when such were present. Fungous growths on dry leaves, on decaying fruit, and on moist dead wood were only capable of sustaining them as long as the moisture was conserved. Fungus found on earth moistened with molasses sustained 9 sowbugs thirty-six days, and 2 survived as long as seventy-five days. Green cotton leaves alone will sustain the life of these crustaceans longer than any other simple condition tried—thirty-two days being the longest any remained alive under these conditions. The other vegetation provided was not favorable, and the sowbugs seemed rather to keep alive on the moisture from the blotter or on the fungus-covered decayed leaves; thus, rose buds and leaves, and the leaves of violet, mint, and chrysanthemum were untouched by the sowbugs. These leaves did not retain their moisture long after picking. When moist earth alone was provided, some found sufficient food to sustain life eighteen days. Additional proof that nourishment is sought in the soil was obtained by mixing London purple or Paris green with the earth. Death always resulted very quickly. When other conditions were unfavorable it was often found that some were sustained by feeding upon the bodies of their dead associates, which were completely devoured. The molted skins were generally devoured.

Experiments with the cattle tick (*Boophilus annulatus* Say) and its eggs evidenced the fact that the sowbugs fed on the dead ticks and ate the eggs when no other food was present. Thirty-eight sowbugs were furnished with a large number of eggs of the tick, and it was found that in several instances as many as 13 tick eggs each were eaten per day for a series of days. This, however, was a maximum, the average during the conduct of the experiment being about 3 eggs per day each. Experiments to find whether the sowbugs fed upon the pupæ of a cutworm (*Prodenia ornithogalli* Guen.) proved futile.

A series of outdoor tests was also conducted with baits to find what substances might be used to attract these crustaceans, and finally a series of poison tests to ascertain the most advisable remedy.

Bread proved attractive, but as every piece tried was carried away by some mammal or bird its use seemed inadvisable. Flour, bacon, potatoes, radishes, and sugar proved to be good baits. To ascertain the relative value of different insecticides several poison tests were conducted with pyrethrum, Paris green, London purple, and arsenic. Few dead sowbugs were found, however, and it was noticed that a

less number approached the poisoned baits than those not poisoned. A series of tests with repellents showed that barriers of powder—whether pyrethrum, arsenic, London purple, or Paris green—proved obnoxious, the sowbugs quickly turning away to avoid the danger, and showing, by the frantic waving of the antennæ, that they had a perception of something wrong. London purple seemed the least repellent and yet practically as effective as any of the others. Sowbugs placed in a jar with a biscuit rolled in arsenic became frantic and died in a few minutes, as did others placed in jars with earth mixed with either London purple or Paris green.

After sprinkling Paris green under boards which had been favorite haunts of the sowbugs, no more live specimens could be found, although each day several dead ones were discovered. In April, when the sowbugs were doing considerable damage to the cotton, a mixture of Paris green and lime was dusted on and around the sprouts with the result that under the poisoned plants great numbers of dead sowbugs were found. No dead could be found around the unpoisoned plants. The dusting was harsh treatment for the plants, being in many cases fatal. It is, however, as proved by other tests, unnecessary to dust the plants. The poison will be picked up by the sowbugs in foraging over the ground.

Under a roll of wire matting in his back yard the writer found the sowbugs so abundant that they crawled over each other in their haste to get away. Having very little poison on hand, he sprinkled what he had of Paris green, London purple, and arsenic over the ground in an area of about 1 square yard and rolled back the matting. Next morning he found 21 sowbugs alive and over 800 dead. Those alive died in a few days, apparently from the effects of the poisoning. The poison washed from these dead sowbugs and used to saturate the soil in jars in several experiments proved fatal to all sowbugs placed in the jars.

Kerosene emulsion as a contact spray was fatal. In spraying a water barrel with kerosene the writer generally sprayed the ground around it also, with the result that the sowbugs were always killed.

These experiments and tests were supplemented by numerous observations of actual conditions from which also data may be derived regarding means of control.

Concerning the plant-feeding habits, definite proofs were obtained as follows:

May 25, at 7.30 a. m., sowbugs were noted at various distances above the ground feeding on the foliage of weeds and honeysuckle. On June 30, at 7 a. m., three sowbugs were discovered feeding on weeds, and one at 8 feet above the ground feeding on a honeysuckle leaf. Nine others were found on the honeysuckle vine at various heights up to 3 feet; also two on grass blades and seven on the

ground under the honeysuckle. On July 3, at 7.30 p. m., the sowbugs were just commencing to climb the various plants, and none were feeding as yet. On the honeysuckle 19 were seen at various heights up to 3 feet, and all but two on the stems and moving upward.

The following definite proofs of the scavenger habits of this sowbug were obtained: May 17 a dead rat near the house was found covered with a great number of sowbugs and almost entirely eaten, even the skin being eaten in places. At another time several sowbugs were discovered diligently cleaning a peach pit.

Concerning the haunts of these animals the following observations were made: In April and May there was considerable moisture, and under every shaded, moist board, cinder, and clod, and under straw, refuse, garbage, and carrion, one could easily find many adult sowbugs and multitudes of young. In the cotton patch, at the base of each plant, the ground became cracked, and here sheltered great numbers of sowbugs, which very likely did injury to the roots. May 17, under the trees and in shady places, the sowbugs were so plentiful that at every step numbers were crushed. July 3, at 8 p. m., sowbugs to the number of 14 were found on an oak tree, the highest being 5 or 6 feet above the ground. July 26, in the late afternoon and early evening, some five dozen sowbugs were found in cracks and holes on three trees, many of them as high as could be seen.

Regarding the effect of natural and field conditions upon these crustaceans certain notes were made. Susceptibility to varying weather conditions was very noticeable. May 25, at 7.30 a. m., a large number of sowbugs had gathered at baits. At 8 o'clock a sudden storm commenced to rise. The sowbugs seemed immediately conscious of danger and hastened in all directions for the highest shelter possible, gaining protection on the fence and beneath the clapboards of the house. All were out of sight when the first drops of water fell. In April and May there was considerable rain, and during the periods of sunshine, at whatever time of day, the sowbugs were to be seen everywhere, crawling over the sidewalks and pavements. April 23 and 24 the ground was drenched with water, and on the 25th dead sowbugs were to be found everywhere on the ground and on the sidewalks. On June 3 a similar observation was made in a spot where the water had stood for several days. By June 15 the intense heat had driven the sowbugs from the open so that few could be found in unprotected places.

The writer's notes upon the biology of the isopods are based on observations of about a thousand individuals in the large series of experiments that has been already referred to.

Copulation was frequently noted out of doors during April and May. The males may be distinguished from the females by their colors as well as by the specific sexual characters. They are a

dark slaty blue, while the females are lighter and have yellow markings.

The period of incubation in this species is long, between fifty-six and ninety-three days, according to the varying results obtained. As no individuals were secured in copula, the exact time of its duration was not recorded. The development of the eggs may be watched from the exterior. The females should be treated very carefully, but with a lens one may see on the ventral side, in the marsupium, the distinct form of the eggs, and may notice the increase in size and finally note the young embryos and the little white young. One experiment with 10 females was most fruitful in giving data on this point. On May 8, June 16, and July 8 young had been produced, and on examination on July 26 all were found to be unfertilized except one, which had eggs apparent. On August 7 the fertile female produced a brood of young. This was ninety-three days after being placed in captivity. A male was admitted on July 26, and on September 30 a brood of young was produced. This would indicate a period of incubation of, at the most, sixty-eight days. In another experiment a female which had just produced a brood of young was placed with 3 males on August 7. On October 2 a brood of young was produced, making the period of incubation fifty-seven days. The number of young in a brood varied from 29 to 79.

The little isopods are pure white when they leave the marsupium. They have six pairs of legs. Within twenty-four hours of birth they molt, and still have only six pairs of legs. Between the fourteenth and eighteenth days another molt takes place and the resulting third instar has seven pairs of legs. The young continue to grow and molt, having been observed in the act of molting on the twenty-eighth, thirty-sixth, fifty-eighth, and sixty-eighth days. After the first molt there is no regularity as to times of molting in the brood, all depending on the food supply. After the first molt a slight darkening of the intestines is noted, and by the twenty-first day the sowbugs are of a gray color throughout and under 3 mm. in length. In fifty-eight days they have not increased beyond 4 mm. in length. The greatest size of any found was 15 mm. This specimen was probably several years old. Females not over 7 mm. long are capable of reproduction.

Before molting, the body of all sowbugs becomes a very dirty gray color. The act of molting is peculiar. At first a white border indicating the loosening of the old skin appears at the front edge of the fifth free thoracic segment, then another on the sixth, and still another on the seventh. Finally the entire posterior half of the skin is free and the isopod steps out of it. This process consumes about twenty-four hours, and when completed the posterior part of the body is of fresh slate color, while the old anterior part appears

very dull. Following the first stage of the molt the anterior segments commence to loosen and are slid forward. The dorsum of the third and fourth thoracic segments is loosened before the legs of these segments are released. From then on the last two pairs of legs in the very young and the last three in later stages are used to hold the animal in position. The anterior legs are not available for use for some time after they are free. The antennæ are withdrawn last.

Regeneration of parts takes place in the antennæ and legs. Several times individuals with aborted members were noticed. These latter would gradually attain full length, then budding of the succeeding segment would be noted and finally this member would be normal. The regenerated part is white for some time.

REMEDIES.

In the treatment of sowbugs poisoned baits are standard remedies. The great fondness of sowbugs for potatoes long ago led to these being used, poisoned either with Paris green or London purple. The potatoes are sliced and a thin covering of powder applied. Sprinkling the soil around an injured plant with Paris green, or dusting the same under boards and other haunts of the sowbugs is also very effective. If the sowbugs are injurious in a garden patch—after treating the ordinary haunts—it is best to keep the ground well broken and raked to prevent clodding and cracking, which gives them protection. Old boards, cans, and rubbish should not be allowed to accumulate. Such precautions will tend greatly to prevent any great damage or annoyance.

Carbon bisulphid has been recommended for the treatment of sowbugs in greenhouses and dwellings, but no special experiments along this line have been tried by the writer.

PORCELLIO LÆVIS Latr.

Porcellio lævis Latr. is a lighter colored sowbug than the preceding, and does not roll up in a ball when disturbed, but instead runs rapidly away to cover. The only definite point in favor of considering it as naturally a plant feeder was the discovery of one dead specimen under cotton dusted with Paris green. It was found, however, that the best way to keep this species alive in the laboratory was to furnish it with fresh cotton leaves and loose mixed soil. Sowbugs of this species were not found far from the barns, and were not numerous in the laboratory cotton patch. They were generally under moist, dark objects and seemed to prefer damp wood piles. Several were found with Armadillidium in crevices and in trees at various heights. One Porcellio was found in the skeleton of a carabid beetle, which was entirely eaten out. In numerous cases this

species was found devouring those of its own kind. The molted skin is usually eaten. A chest of old clothes, which had been wet in a flood, was found to be literally alive with this sowbug. Experiments with eggs of the cattle tick (*Boophilus annulatus* Say) gave the following results: Four sowbugs provided with over 300 eggs devoured 153 at the rate of between 5 and 6 a day each.

The broods of this species are small, numbering from 8 to 30. Metamorphosis is more rapid than in Armadillidium. The seventh pair of legs is attained before the twelfth day. Molting is as in Armadillidium.

The same remedies as recommended for Armadillidium were found to be effective.

METOPONORTHUS PRUINOSUS Brandt.

Metoponorthus pruinosus Brandt is a much rarer sowbug than either of the two preceding species. It is also more delicate and more agile. The color is a beautiful blue-gray in the male and somewhat tinged with red in the female. Its haunts are damp, earthy places in sheds, etc.

These sowbugs feed very eagerly on cotton leaves and were kept under the same condition as the two preceding species. Forty tick eggs were eaten by two individuals at the rate of about 7 per day each. They may be poisoned by dusting the soil in their haunts with arsenicals.

Reproduction and development is very rapid, much more so than in either Armadillidium or Porcellio. One pair produced four broods of young in sixty-two days, there being seventeen, sixteen, and twenty-one days between broods. The broods are small. The young grow so rapidly that in two months they are one-half as large as their parents. They molt frequently. It is very difficult to observe this species closely because of its rapidity of movement.

CONCLUSIONS.

In conclusion it may be said that (1) in a damp year the sowbugs may do considerable damage to the young growing vegetable crops; (2) they serve at all times as scavengers; (3) their exclusion from houses is advisable because of the scavenger habit, there being a possibility of the transmission of diseases; (4) in the case of the cattle-tick problem they may be beneficial by eating such eggs as are deposited in barns, sheds, pens, in the woods near the watering places, and in moist meadows. Finally, cleanliness is probably the best preventive against sowbug inroads, arsenical compounds the best outdoor remedies, and carbon bisulphid the best indoor remedy.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part III.
L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON "PUNKIES."

BY

F. C. PRATT,
Special Field Agent.

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U. S. D. A., B. E. Bul. 64, Part III. Issued April 2, 1907.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON "PUNKIES."

(*Ceratopogon* spp.)

By F. C. Pratt,
Special Field Agent.

INTRODUCTION.

While in the Blue Ridge Mountains near Bluemont, Va., a few years ago the writer heard reports concerning "biting gnats," which were said to bite furiously before rains. At that time his stay was of short duration, and a dry summer prevented him from securing specimens. In 1904, however, during another visit to the same locality one rainy week, July 21–28, he was harassed by myriads of these minute flies, which were extremely numerous and active after as well as before rains. They proved to be *Ceratopogon guttipennis* Coq., one of the smaller Chironomidæ. Mr. D. W. Coquillett has recently made a careful systematic study of the specimens belonging to the genus Ceratopogon contained in the United States National Museum collection, including those reared at the insectary of this Department and by the writer, and the determinations of the species here mentioned are his. The records of these rearings are brought together in the present paper with the addition of such data as have been communicated by collectors and correspondents.

Prior to 1902 little had been published on any of these pernicious insects beyond scattered notices such as were furnished in a previous bulletin[a] of this Bureau, on the bite of *C. stellifer* Coq. in Texas. As the bibliographic references have never been collected, the writer has brought together all data and accompanying illustrations, with such references to the biting and other habits of this group as he has been able to find.

CERATOPOGON GUTTIPENNIS Coq.

The flies of the species *Ceratopogon guttipennis* will bite any exposed part of the body, preferring, however, the hairy parts. At one time 25 individuals were counted in the hair on the head of the writer's 8-year-old boy guide at Bluemont, Va. They are persistent in their endeavors to obtain blood, piercing the skin and filling up with blood so as almost to lose semblance to flies. In many cases an itching

[a] Bul. 44, Div. Ent., U. S. Dept. Agric., p. 92, 1904.

pimple results from the punctures, the eruptions, in appearance,

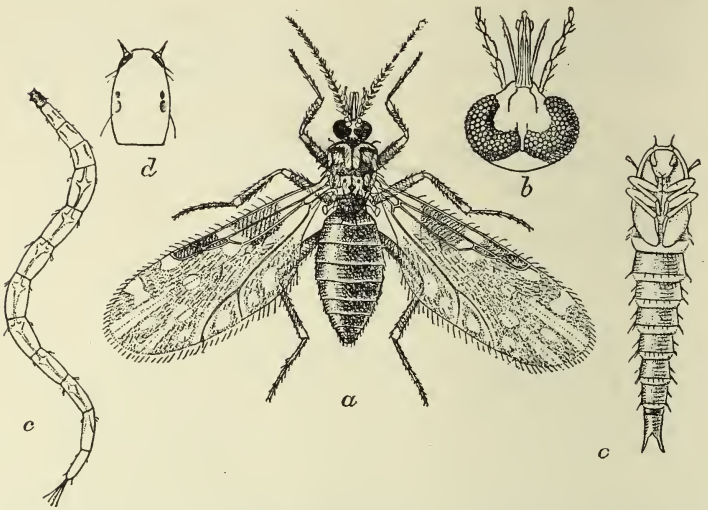

FIG. 3.—*Ceratopogon guttipennis: a*, adult; *b*, head of same; *c*, larva; *d*, head of same; *e*, pupa. All greatly enlarged (original).

being very much like the vesicles caused by contact with poison ivy. The adult is a minute fly 1 mm. in length, appearing blackish to the naked eye, but under a lens seen to be of a deep gray hue, with mottled wings (fig. 3). Its mouth parts are illustrated in figure 4. The species was described by Mr. D. W. Coquillett,[a] to whose paper the reader is referred for descriptions of many species of this genus. The Virginia punkie is the name which the writer would suggest for this particular species, as it may possibly be distinct from the one occurring in Maine which the Indians called "no-see-um," and which is popularly known as "punkie," the latter name being corrupted according to locality. The flies of this species are very troublesome to man and domestic animals. If milking is put off later than usual in the morning, they drive the cows almost frantic by their persistence, and while that process is going on the operator, having both hands engaged, is at their mercy.

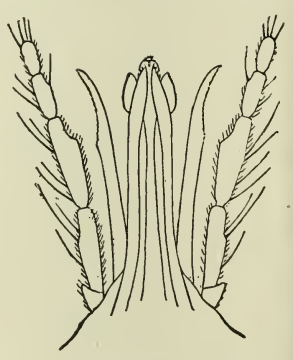

FIG. 4.—*Ceratopogon guttipennis:* Mouth parts of adult. Highly magnified (original).

THE LARVA.

Larvæ were found in the very dirty water in holes in the middle of poplar stumps, in company with larvæ of mosquitoes (*Anopheles bar-*

[a] Proc. U. S. Nat. Mus., Vol. XXIII, No. 1225, p. 603, 1901.

beri Coq., *Culex signifer* Coq., and *C. triseriatus* Coq.), larvæ of the dascyllid beetle *Prionocyphon discoideus* Say, and a rat-tailed maggot related to Eristalis. Eggs could not be found on account of the dirty condition of the water. The larval food seems to be the débris at the bottom of the holes, as well as dead mosquito and other larvæ, and cast larval and pupal skins. In one instance the larvæ had accomplished the complete disintegration of a rat-tailed maggot, and the writer has seen them render the skin of the beetle larva just referred to transparent. On several occasions larvæ were seen inside the skin. They were taken also at Woodstock under similar conditions, that is, in holes containing water in living trees.

The larva (fig. 3, *c*), when full grown, is 4.7 mm. in length and very slender. It has 12 segments exclusive of the head, the two segments following the head together being about the length of each of the other segments. It is white in color, threadlike, and has a brownish head. Locomotion is undulatory. The larvæ frequently come to the surface and then descend, squirming along the bottom of a jar and apparently never remaining quiet, as does the larva of Culex at times. Some of the larvæ were carried through the winter in a room which was moderately cool, but seldom near freezing. From these over-wintered larvæ adults issued April 27 to May 8, 1905. Later investigation may prove that the larvæ freeze up just as do the larvæ of some mosquitoes, then thaw out in the spring and complete their life cycle.

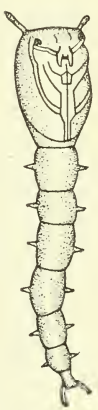

Fig. 5.—Pupa of *Ceratopogon varicolor*. Much enlarged (after Dyar).

THE PUPA.

The pupa (fig. 3, *e*) is 3.01 mm. in length and 0.84 mm. in breadth. It is of a brown color, a little more than half as long as the mature larva, but much stouter, and has eight abdominal segments, each succeeding segment being narrowed to the last, which is bifurcated, the claspers being 0.35 mm. in length. It is provided with two short breathing tubes. In this stage the insect does not move frequently, remaining in a perpendicular position in the water just below the surface. For comparison the figure of an allied species, *C. varicolor* Coq. (fig. 5), from Bellport, N. Y., is reproduced from Plate I, Volume V, of the Proceedings of the Entomological Society of Washington.

The known distribution, gathered from specimens in the U. S. National Museum collection, is as follows: Plummers Island, Md., June 6 (H. S. Barber); Medina, Ohio, August 5 (J. S. Hine); Bluemont, Va., July 29 and 30, and Woodstock, Va., August 8 and 9 (F. C. Pratt); Santa Rita Mountains, Arizona, July 8 (E. A. Schwarz).

A specimen of *Ceratopogon guttipennis* has recently (April 13, 1906) been reared from a larva collected from water in a hollow living tree

at Dallas, Tex., April 9, 1906, under conditions similar to those at Bluemont and Woodstock, Va. This water had been frozen during the winter.

OTHER SPECIES OF CERATOPOGON.

There are nearly one hundred known species of Ceratopogon represented in the U. S. National Museum collection, and several species besides the one under discussion are known to bite, among them

FIG. 6.—*Ceratopogon stellifer:* Adult. Highly magnified (original).

C. sanguisuga Coq., *C. stellifer* Coq., *C. variipennis* Coq., *C. unicolor* Coq., and *C. cinctus* Coq. Many others will undoubtedly be found to have similar habits.

C. sanguisuga Coq. has been collected at the following localities: Marlboro, Md., May 13 (H. S. Barber); Woodside, Md., October 12 (J. E. Benedict, jr.); Kaslo, British Columbia, June 29 (H. G. Dyar).

C. stellifer Coq. (fig. 6) is a little smaller than *C. guttipennis* and is a most notorious biter. Its distribution, as shown by specimens in the U. S. National Museum, is as follows: District of Columbia, May 12, June 6, September 9 (H. S. Barber, collector); Fairfax County, Va., August 18 (J. E. Benedict, jr.); Corinth, Miss., August 19, and Athens, Tenn., August 22 (H. S. Barber); Las Vegas Hot Springs, N. Mex., August 7, 11, and 19, and Hot Springs, Ariz., June 27 (H. S. Barber).

C. variipennis Coq. A female of this species was collected while sucking blood by W. P. Cockerell at Las Vegas, N. Mex., May, 1902, and has been collected at Westville, N. J., in June, by J. B. Smith and on July 2 by C. W. Johnson; also at Richmond, Va., by Mrs. A. T. Slosson, and at Mexico City, Mexico, by O. W. Barrett.

C. unicolor Coq. has been taken at Eureka and Fieldbrook, Humboldt County, Cal., by H. S. Barber in May and June.

C. cinctus Coq. was found at Lake Worth and Biscayne Bay, Fla., by Mrs. A. T. Slosson, who braved its biting in order to collect specimens of it.

C. websteri Coq. was collected April 17, 1887, by Prof. F. M. Webster at Ashwood, La., on bushes in company with a species of Simulium.

C. mutabilis Coq., reared from human excrement by the writer in the District of Columbia June 17, occurs also at Jacksonville, Fla. (Mrs. A. T. Slosson, collector).

C. griseus Coq. was captured on human excrement by the writer at Travilah, Md., in June. It has been collected also in Florida and Arizona, and Prof. T. D. A. Cockerell found it on a horse at Pecos, N. Mex. This species, as well as *C. mutabilis*, were recorded by Dr. L. O. Howard in an article on the insect fauna of human excrement as "Ceratopogon species." [a]

C. specularis Coq. was reared by Mr. C. L. Marlatt from horse and cow manure during his investigation on the horn fly (*Hæmatobia serrata* R.-D.) in Virginia in 1889. It has been collected also at Springfield, Mass. (Dimmock); Philadelphia, Pa., June 28, and Natrona, Pa., July 30 (C. W. Johnson); District of Columbia, August 11 (F. C. Pratt); Woodside, Md., October 12 (J. E. Benedict, jr.); Warrenton, Va., August 23, and Rosslyn, Va., December 30 (C. L. Marlatt), and in Colorado.

W. H. Long [b] found larvæ of this species on the under side of dry cow dung from August to December, but more abundantly during November and December, in company with *C. brumalis* at Austin, Tex.

C. brumalis Long. Mr. W. H. Long writes of this species as follows: [c]

> During November, December, and January the larvæ of this species were found in immense numbers on the under side of nearly dry cow dung. They seem to feed on the dung, never penetrating very far into the substance. No eggs were found. The duration of the larval stage seems to be several weeks, that of the pupal stage seven to ten days. * * * Several hundred larvæ of all ages were found on the under surface of a piece of moist rotting elm wood; similar larvæ and puparia were also found in the nests of the common foraging ant (*Eciton cœcum*) on several different occasions.

Mr. Long states that he reared imagines from larvæ taken in these various situations and they proved to be the same species. It is known from Austin, Tex.

C. stenammatis Long. Long writes of this species as follows: [d]

> The specimens were received from Dr. W. M. Wheeler, who found them in the nest of an ant (*Stenamma fulvum* subsp. *aquia*) at Colebrook, Conn., August, 1900. They were moving about in the refuse heaped up by the ants in certain portions of their nests. The species seems to be a genuine myrmecophile like the European species (*C. Braueri* Wasmann).

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[a] Proc. Wash. Acad. Sci., Vol. II, p. 559, 1900.
[b] Biol. Bul., Vol. III, pp. 7–10, figs. 3–6 (in part), 1902.
[c] L. c., Vol. III, pp. 3–7, figs. 1, 2, 6 (in part).
[d] L. c., p. 10, figs. 4, 6 (in part).

C. texanus Long.

The larvæ of this species are gregarious in small numbers beneath the bark of old dead trees in moist places, or on the under side of very damp rotting wood during December and January. Rare.[a]

Austin, Tex.

C. wheeleri Long. Adults of this species have not been reared on account of a proctotrypid parasite (*Adeliopria longii* Ashm.).

The Ceratopogon puparia were found December 15, 1900, beneath a stone, in what seemed to be an abandoned ant's nest. The parasites issued, one from the thoracic dorsum of each of the Ceratopogon puparia December 31 and lived eight or ten days.[b]

Austin, Tex.

The late Dr. O. Lugger[c] calls attention to the "cussedness" of an unidentified species and gives a figure which may possibly be *C. stellifer*. Ceratopogon has also been recorded as breeding under leaves and in flowing sap from trees; thus the group is seen to have diversified habits.

In Europe, Professor Mik[d] described as *Ceratopogon hippocastani* a hairy-winged species having a footless larva, found in the very moist or wet ulcerous parts of stems of horse-chestnut (*Æsculus hippocastanum*).

OTHER BLOOD-SUCKING CHIRONOMIDÆ.

A related form which may be mistaken for Ceratopogon is *Œcacta furens* Poey, taken in June at Cardenas, Cuba, by Mr. E. A. Schwarz, and at Montserrat, West Indies, April 8, by Mr. H. G. Hubbard. It was also taken at Perihueta and Laguna Carmen, Mexico, by Dr. Alfredo Dugès.

Another related form, *Tersesthes torrens* Towns., described by Prof. C. H. T. Townsend[e] with notes on habits, has been collected at the following localities: Filmore Canyon, and Las Vegas Hot Springs, N. Mex. (Townsend); Fort Grant, Ariz., July 19 (H. G. Hubbard); Ash Fork, Ariz., June 18 (H. S. Barber); Lake Worth, Fla. (Mrs. A. T. Slosson); Salt Lake, Utah (H. S. Barber), and Baracoa, Cuba, August (A. Busck).

Mr. Barber has collected from thirty to forty species of Ceratopogon and states that Tersesthes is much worse as a pest than any Ceratopogon he has ever encountered.

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[a] Long. L. c., pp. 10–12, figs. 5, 6 (in part).
[b] Long. L. c., pp. 12–14, fig. 5 (in part).
[c] Second Rept. Ent. of Minn. Exp. Sta., pp. 171–172, fig. 142, 1896.
[d] Wiener Ent. Ziet., Vol. VII, pp. 183–192, Pl. II, 1888.
[e] Psyche, Vol. VI, pp. 369–371, pl. 8, 1893.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part IV.
L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

AN INJURIOUS NORTH AMERICAN SPECIES OF APION, WITH NOTES ON RELATED FORMS.

BY

F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

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By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

In economic works of European authors a very considerable number of species of Apion are mentioned in connection with injuries to cultivated plants, and particularly to the Papilionaceæ, for which a large proportion of species show a preference. Certain European forms are sufficiently abundant to receive common English names, among which are the clover weevil, the Dutch-clover yellow-legged weevil, the cinquefoil weevil, the tare or vetch weevil, and others, the popular name being indicative of each insect's food habits.

None of our native species, so far as known to the writer, has hitherto been recorded as injuring useful plants; hence a note received from Mr. James K. Metcalfe, Silver City, N. Mex., of injuries to forage plants by *Apion griseum* Sm. is of interest.

APION GRISEUM Sm.

September 25, 1899, our correspondent sent seedpods of the Metcalfe bean (*Phaseolus retusus*), together with specimens of the beetle. This weevil was stated to be very destructive to this plant, which has been mentioned by Dr. Jared G. Smith as one of the most promising of our native forage plants.[a] The weevil was said to be also destructive to the "Raphael" bean (*Phaseolus wrightii*), and we have received the same species from Phaseolus beans from Tolima, Mexico.

This species has also been observed by the writer to develop in the seedpods of a wild bean, *Phaseolus polystachyus* (*perennis*). Eighteen individuals were found on opening a pod of this plant at Rosslyn, Va., April 22. One seed had harbored eleven Apions, all of which perished owing to their inability to escape from the pod,

[a] Yearbook, U. S. Department of Agriculture, for 1897, p. 506.

which had evidently died prematurely as a result of overinfestation by the weevils. Pods were examined during the first week of October, and at this time half of those gathered were infested. The sound pods may be easily separated from the infested ones, since the latter are flattened, discolored, and sometimes even distorted, while sound and fully matured pods are full and round like a diminutive pea-pod. Most individuals were in the pupal condition at the last-mentioned period. The adults, like others of the genus, feed upon the leaves, piercing them with innumerable holes, from 20 to as many as 60 such punctures being sometimes visible on a single small leaf.

The insect hibernates in the beetle condition, escapes from the pod about May or June, or earlier if the pod happens to crack, and the punctures made upon the early appearance of the insect are plainly visible in October.

Careful comparison of the writer's reared material of *Apion griseum* with typical specimens in the U. S. National Museum (some of which appear to be types) of *A. fraternum*, identified as such by Dr. J. B. Smith, who described that species, shows that this is the same insect which was found by Dr. C. V. Riley on *Strophostyles* (*Phaseolus*) *pauciflora* as cited by Smith. The identity of these two forms has also been recognized by Fall in his revision of the genus.[a]

The chalcidid fly *Catolaccus incertus* Ashm. was reared from infested pods, and is undoubtedly parasitic on this Apion.

APION COLON Sharp.

February 6, 1903, Dr. Edward Palmer furnished specimens of this species collected at Alvarez, San Luis Potosi, Mexico, on a species of wild bean with scarlet flowers and tuberous roots, which is used as a cure for hydrophobia (Palmer's No. 63).

FIG. 7.—*Apion assimile*, greatly enlarged.

This species is not known to occur in our limits, but is mentioned because of possible economic importance.

The accompanying illustration (fig. 7) represents a European species, and will assist the average student of entomology in recognizing weevils of the genus. Upward of 100 species of the genus Apion have been recognized in America north of México, and most of these are minute or almost microscopic. It follows, therefore, as there is considerable generic resemblance throughout, that these many different forms are difficult of differentiation, both sexes being frequently required to make specific determination. The body is

[a] Trans. Amer. Ent. Soc., Vol. XXV, p. 147, 1898.

elongate pyriform, or pear-shaped; the rostrum or beak is more or less prolonged in front of the eyes, and the head back of the eyes is usually constricted, forming a neck. The antennæ are delicate and elbowed.

NOTES ON RELATED FORMS.

The following observations on other species of Apion are chiefly from the writer's personal experience, and all rearings should be so credited, with the exception of those where the collector or observer is mentioned:

Apion æneipenne Sm.—During the first two weeks of June numerous examples of this species were obtained at Rosslyn, Va., by beating a common tick-trefoil (Meibomia [Desmodium]). When the beetles were confined with leaves they riddled them with minute holes after the manner of the commoner *A. nigrum* on locust.

Apion turbulentum Sm.—This species was observed during the latter half of September in and near Cabin John, Md., and in considerable numbers on *Meibomia marylandica*. The beetles were numerous, occurring on the seeds, in which they undoubtedly live, although they were not reared.

Apion cribricolle Lec.—We have, among the Department notes, one on the rearing of this beetle from a species of lotus (*Lotus* [*Hosackia*] *glabra*) from Henwood, Santa Cruz County, Cal.

Apion proclive Lec.—July 18, 1898, Mr. E. M. Ehrhorn reported that this species was infesting the pods of *Lupinus arborea* at Pacific Grove, Cal., where nearly every pod showed signs of attack. A similar attack to lupine was reported by Mr. Ehrhorn in 1907 at San Francisco, Cal. The beetles issued September 5–19. The species proves to be parasitized by a chalcidid.

Apion patruele Sm.—This species was found abundantly on a climbing wild legume at Cold Spring Harbor, Long Island, N. Y., in July. The plant at this time was in bloom, and there is little doubt that the larva inhabits the pods.

Apion segnipes Say.—The writer has reared from this species, found in its well-known food plant, the goat's rue (*Cracca* [*Tephrosia*] *virginiana*), the chalcidid parasite *Eurytoma tylodermatis* Ashm., in August, in Maryland, near the District of Columbia. The writer has also reared this species from its larva found in the cells of *Tyloderma foveolatum* in October. There is fair indication, therefore, of two generations.

Apion decoloratum Sm.—This species breeds in the seed pods of the genus Meibomia. Beetles have been reared from *M. paniculata* and *M. grandiflora*, and exit holes have been observed in pods of all of the species of this genus of plants that have come under observation in Maryland and Virginia about Washington. The beetles began

issuing from the pods September 21, and most of those in the field had escaped by the end of the month. Stragglers, however, continued to issue from the material gathered until the end of October. Mr. Fall states that "Mr. Wickham has found the species in some abundance on Desmodium in Iowa City." *Catolaccus incertus* Ashm. was reared with this species.

Apion herculanum Sm. was reared July 24–28 from the dried fruit of sheepberry (*Viburnum lentago*), and beetles were taken in the same locality, Marshall Hall, Md., in May on *V. acerifolium* in bloom. At Ithaca, N. Y., it was taken in fair abundance on the flowers of this same plant, collected May 28, June 5–20, and July 2–6 several years previously. Mr. Schwarz informs the writer that he has reared the species also from dogwood (*Cornus* sp.).

○

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BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part V.
L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

INSECTS INJURIOUS TO THE LOCO WEEDS.

BY
F. H. CHITTENDEN, Sc. D.,
Entomologist in Charge of Breeding Experiments.

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For many years the Bureau of Entomology has conducted correspondence in regard to insects found on the loco weeds of the semiarid regions of the West. In earlier years these insects were found chiefly on purple or woolly loco, *Astragalus mollissimus*, and more recently on the white loco, *Aragallus lamberti*. It was at one time supposed by stockmen that the insects might be the cause of the poisoning to sheep, cattle, and other stock, but such is not the case.

The general subject of loco poisoning to stock has been treated in various publications, but the insect inhabitants of the weeds have never received mention in this connection, with the exception of the false-indigo gall-moth,[a] which is apparently the principal insect destroyer of the loco. Numbers of correspondents and observing botanists have noticed that the caterpillar of this insect, which feeds at the roots and crowns of locos, is quite instrumental in reducing their abundance. Recently Dr. C. Dwight Marsh, Bureau of Plant Industry, has collected many insects on locos and expresses the opinion that several other species are concerned in this work. Chief among these are the fickle midge,[b] the loco root-maggot,[c] the four-lined loco weevil,[d] and the spotted root fly.[e] Of these the root-maggot, midge, and root fly are probably in the main attracted to the plants after the gall-moth has first caused injury, but the weevil also attacks living roots, usually, however, according to observations, after the plant has produced its quota of seed.

The following account of loco insects has been prepared from the records of the Bureau of Entomology, much of the material having also been supplied by Doctor Marsh, and in the list which follows it

[a] *Walshia amorphella* Clem.
[b] *Sciara inconstans* Fitch.
[c] *Pegomya lupini* Coq.
[d] *Cleonus quadrilineatus* Chevr.
[e] *Euxesta notata* Wied.

will be understood that the locality Hugo, Colo., is the one in which he collected specimens for identification. This account does not pretend to be an exhaustive one, but is more in the nature of a list, with notes on such species as appear to be concerned in killing out the weed. Considering the toxic qualities of the locos, the insects which affect them, with some exceptions, may be classified as highly beneficial, since the species which have just been mentioned have in some cases completely rid large areas of loco weeds.

THE FALSE-INDIGO GALL-MOTH.

(*Walshia amorphella* Clem.)

Prior to 1886 the larva of this species was known only as a gall maker on the stems of false indigo (*Amorpha fruticosa*) and was described from moths reared from that plant in 1864. An account of the species and its habits was afterwards given by Riley in 1870.[a] He stated that as the twigs invariably withered and died above the gall, and as the shrub was of no special value, the species might be placed among our harmless insects. In early records of the Bureau of Entomology there are numerous references to this species and its occurrence on false indigo. In 1886 a second food plant, *Astragalus mollissimus*, was recorded.[b]

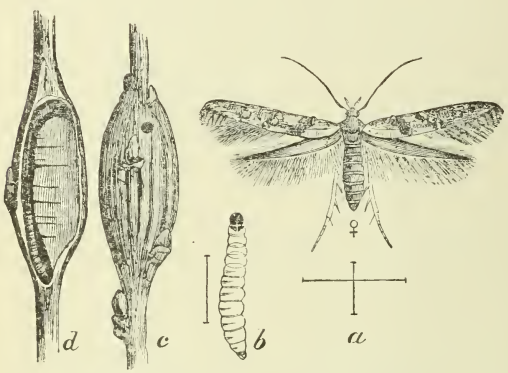

FIG. 8.—False-indigo gall-moth (*Walshia amorphella*): *a*, Female moth; *b*, larva; *c*, gall in false indigo, showing exit hole near top; *d*, gall opened, showing larva *in situ*. *a*, *b*, 3 times natural size; *d*, *c*, natural size. (After Riley.)

This moth (fig. 8, *a*) belongs to the family Tineidæ and has a wing expanse of about half an inch. It is grayish yellow, spotted with dark brown, and both wings are provided, as in others of this group, with very long posterior fringes, longer than the wings themselves. The larva or caterpillar (fig. 8, *b*) is yellowish white, with the head and thoracic plate dark brown. It measures from a third to two-fifths of an inch in length.

Our records of the distribution of this species show that it has been observed most commonly from Iowa and Missouri westward to California, although it occurs also in the Atlantic region. It is quite

[a] 2nd Rept. State Ent. Mo., pp. 132–133.

[b] Proc. Ent. Soc. Wash., Vol. I, p. 30.

singular that the larva should have the dual habit of forming galls on a shrub, as in the case of its occurrence eastward, and at the same time boring into the roots of weeds, as is its western habit. From the experience of many persons who have been in correspondence with this office in regard to the habits of this insect, there can be no hesitation in reiterating that it is the most potent element in the destruction of the loco weed of the West. In this connection it may be well to mention briefly what some of our correspondents have reported. Mr. Thomas J. Quillian, Birmingham, Colo., wrote, April 9, 1889, that from observations conducted by himself and a fellow stockgrower he was led to believe that possibly the "worms" eaten by the stock produced the craziness (and sometimes death) instead of the plant, as was generally supposed, this conclusion being more plausible because upon opening the dead animals many "worms" were always found. Mr. D. H. Marum, Woodward, Okla., has written that in that vicinity the plants begin to die about the last week in May. At that time the small "worms" are found in the roots, which they hollow out completely, leaving practically nothing but a shell. He suggested the possibility of propagating these and other loco insects with a view to destroying the weed. Mr. Thomas Carson, Bovina, Tex., writing of the great loss in cattle in that section, stated that this insect, which he had observed devouring the heart of the loco, was very efficient in reducing the abundance of this noxious weed and had proved very beneficial to the cattle interests. In closing, it should be added that in the extreme west, as, for example, at Alameda, Cal., this species has been observed breeding on *Lupinus arborea*.

THE LOCO ROOT-MAGGOT.

(*Pegomya lupini* Coq.)

The loco root-maggot has been prominent among insects found feeding on the roots of *Astragalus mollissimus* for a number of years. Doctor Marsh says that in the neighborhood of Hugo, Colo., it is apparently the most important agent in the suppression of the purple loco. It is probable that it will rank second to the false-indigo gall-moth as a destroyer of this plant. On this head Mr. George Hochderffer, Flagstaff, Ariz., who, on April 7, 1907, sent specimens found at the roots of the plant, stated that hundreds of acres of loco had been destroyed by this insect, and he believed not only that it might prove to be a valuable friend to stockmen, but that it had already proven so.

It is the larva of a species of anthomyiid fly closely related to the seed-corn maggot,[a] the adult being readily distinguished from that

[a] *Pegomya fusciceps* Zett.

of the latter by the long bristles on the underside of the posterior femora or hind thighs. It was described in 1901 from flies obtained from the stems of *Lupinus alba* from Los Angeles, Cal.[a] This species resembles the common house fly, though more slender and of a more distinctly gray color. The larvæ are white maggots and resemble the seed-corn maggot. They infest chiefly the crown of the plant, seldom, if ever, entering the roots, but penetrating into the larger stems; sometimes, it is reported, going as far as the base of the flowers.

We have records of the rearing of this species from *A. mollissimus* from material collected at Sherlock, Kans., and from *Lupinus arborea* at Alameda, Cal., in April. In June, 1887, it was received from New Mexico with statement by Dr. V. Havard that it was breeding in the roots of *A. mollissimus*. At this time we were conducting considerable correspondence with Doctor Havard in regard to the insect enemies of this plant in Kansas, New Mexico, and Texas. Doctor Havard stated, among other things, that at that time it was somewhat generally believed that "locoism" on the part of stock animals was due, not to any deleterious property of the plants, but to the larvæ of insects found abundantly in the stems and roots. In all specimens received by him from New Mexico the stems, without exception, were bored by the larvæ of this species. Flies from this last lot began issuing June 10. In May, 1905, and January, 1908, this species was again received from locos from Hugo, Colo. In that locality it was associated with *Euxesta notata* and *Sciara inconstans*.

THE FICKLE MIDGE.

(*Sciara inconstans* Fitch).

This minute gnat-like fly was reared from purple loco received from Hugo, Colo., in 1906, the adults issuing May 24. During 1907–8 additional specimens were received from the same source. Doctor Marsh has expressed the belief that this species, with the larger maggot, *Pegomya lupini* Coq., is one of the chief causes of the destruction and apparent temporary extermination of this loco weed in that section of Colorado. The members of the family to which it belongs, the Mycetophilidæ, are for the most part scavengers, feeding on decomposing vegetable matter, including fungous growths, whence their name of "fungus gnats." Taken as a whole, however, the family displays great diversity in habits and the present species is the most widely distributed and most nearly omnivorous of its kind. It feeds on vegetation of almost all forms, occurring destructively in greenhouses, as also in the open, in cultivated and uncultivated regions. It appears to be most abundant in the Northern States.

[a] Ent. News, September, 1901, pp. 206–207.

The insect is shown in its different stages, highly magnified, in figure 9. The size is indicated by the hairlines at the right of the figure. It will be noticed that the female fly (*c*) is larger than the

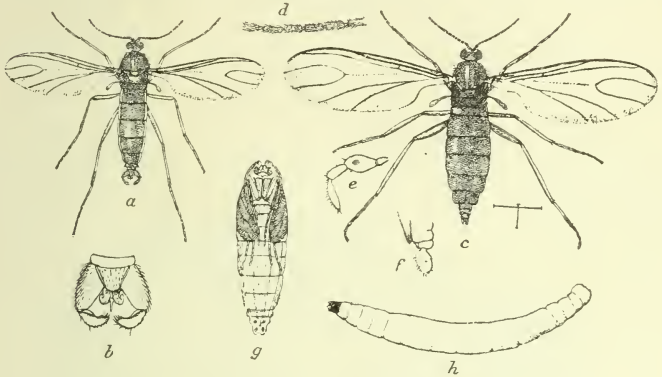

FIG. 9.—Fickle midge (*Sciara inconstans*) : *a*, Male fly ; *b*, external genital organs of male ; *c*, female ; *d*, enlarged antennal joints of same ; *e*, maxillary palpus of same ; *f*, tip of abdomen of female from side ; *g*, pupa, ventral view ; *h*, larva, dorsal view. *a*, *c*, *g*, *h*, Much enlarged ; *b*, *d*, *e*, *f*, more enlarged. (Author's illustration.)

male. The latter (*a*) is recognized by its claspers, shown much enlarged at *b*. The larva is a delicate, thread-like maggot of milk-white color with a jet-black head. On account of its minute size—about $\frac{1}{5}$ of an inch in length—its presence is very frequently unnoticed in greenhouses, although the flies are more conspicuous, from their habit of flying about on the "glass." In some cases this species is confused with nematodes or eel-worms.[a]

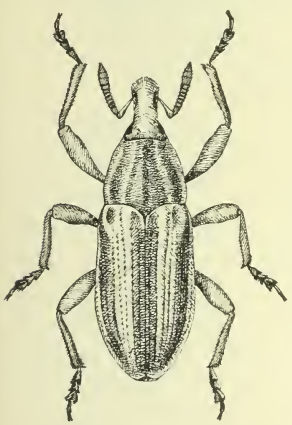

FIG. 10.—Four-lined loco weevil (*Cleonus quadrilineatus*): Adult. Much enlarged (original).

THE FOUR-LINED LOCO WEEVIL.

(*Cleonus quadrilineatus* Chevr.)

This curculionid weevil was found breeding in considerable numbers on *Aragallus lamberti* at Hugo, Colo., during 1907, by Dr. C. D. Marsh, who reports very appreciable injury. As a rule, however, this species does not occur in numbers until after the plants have made good growth and have seeded.

This beetle, (fig. 10) measures about half an inch in length; has a stout rostrum or beak, a little shorter than the thorax; is black, and densely coated with gray pubescence alternating with two pairs of longitudinal black lines, one subsutural and the other submarginal.

[a] A more complete account of this insect appeared in Bul. 27, n. s., Div. Ent., U. S. Dept. Agric., pp. 108–113, 1901.

Practically nothing is known of the life history of any species of the genus, of which there are quite a number. The beetles are partial to Astragalus and Aragallus and feed also on lupines and related plants. The larvæ are undoubtedly root or stalk feeders. The present species in the larval stage affects the roots and transforms in the ground in comparatively large earthen cocoons, such as are shown in the illustration (fig. 11).

FIG. 11.—Four-lined loco weevil (*Cleonus quadrilineatus*): Cocoon. (Original.)

THE YELLOW LOCO FLY.

(*Tritoxa incurva* Loew.)

This species was collected at Hugo, Colo., on *Aragallus lamberti*. It is a two-winged fly of the family Ortalidæ and is recorded as having the same habits as the black onion fly (*Tritoxa flexa* Wied.), whose larva or maggot lives in the bulbs of onions; indeed, it was at one time considered a color variety of the latter. The wing markings are almost identical, but the face, thorax, and most of the abdomen are brownish yellow, whereas in the onion fly these parts are black. Its body is about one-third of an inch long, each wing having a little shorter measurement. Neither species under consideration is, as a rule, especially abundant, but both are capable of being very destructive to plant life when they multiply in numbers, as may happen any year in some localities.

THE SPOTTED ROOT FLY.

(*Euxesta notata* Wied.)

This pretty little fly of omnivorous habits was reared from *Astragalus mollissimus* from Hugo, Colo., in June and July, 1905, being associated with the fickle midge and the loco root-maggot. In its

larval stage it displays a remarkable diversity of habits, although it is evidently by choice a root feeder and is also, with the seed-corn maggot and many related insects, a scavenger by nature, following in some cases original attack by some other form of insect. It has been recorded by Dr. L. O. Howard as having been bred from larvæ in human excrement in houses and out of doors. Mr. E. G. Titus has reared it from sugar beet collected at Olney, Colo., and from cocklebur collected at St. Matthews, S. C., where it was feeding in the cells of a weevil, *Baris transversa*. In September, 1905, it was reared by the writer from onions infested by *Tritoxa flexa* from Williamson School, Pa., and there is positive evidence that it had fed on the onion bulbs, as neither stems nor leaves were present. Dr. J. B. Smith also has reared it from onions. In 1906 it was reared from corn on the farm of Dr. B. T. Galloway near the District of Columbia, where it was reported injurious, the injury being at first attrib-

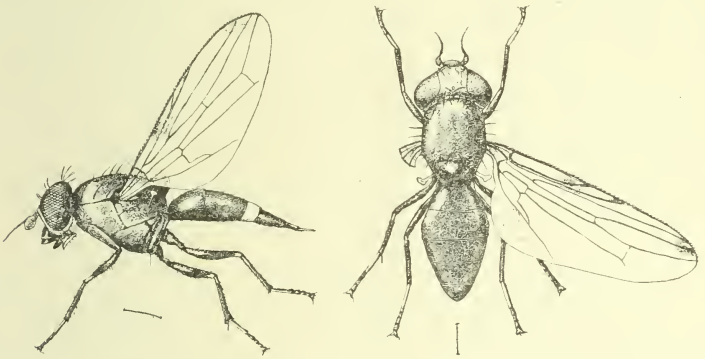

FIG. 12.—Spotted root fly (*Euxesta notata*): Adult male at right; female at left. Much enlarged (original).

uted to the seed-corn maggot, as attack was to seed corn and resembled the work of the latter species. From cabbage it has been reared on two occasions, viz, from the roots collected at Washington, D. C., and from maggot-infested roots received from Bethel, Alaska. It has also been bred from the pulp of Osage orange, from apples infested by the codling moth, from sumach fruit, from the bolls of cotton, and from Solanum. It is not rare in diseased cotton bolls.

This fly belongs to the same family as the preceding, the Ortalidæ, and is shown in figure 12, where it will be seen that it has a large head and flat body. Each wing is marked with two black spots. The female is distinguished from the male by its more slender form, smaller head, and pointed abdomen, which bears near the anal extremity a distinct white transverse band. The body is metallic blue.

Our rearings show that larvæ have come under observation from May 27 to as late as October 2 and that flies have issued from various sources June 10–July 30, September 8–21, and throughout October.

THE BUR-CLOVER APHIS.

(*Aphis medicaginis* Koch.)

This species is well known to attack both Astragalus and Aragallus, as well as various other related plants, including clover, cowpea, alfalfa, coffee bean (Cassia), bur-clover, *Caragana arborescens*, *Robinia viscosa*, *Melilotus italica*, and *Glycyrrhiza lepidota*. It has also been observed on oxalis, and on cotton associated with the common and more destructive cotton or melon aphis.

Certain of our correspondents have remarked on the occurrence of ladybirds and ants on infested loco plants, conclusive evidence in the case of the ladybirds, *Hippodamia convergens* Guér., that aphides were present.

The present species has a considerable literature, having been described in 1857 and afterwards treated more or less fully by Monell, Thomas, Oestlund, Cowen, Osborn, Hunter,[a] and Sanderson.

A somewhat complete account of this aphis was given by Sanderson in 1906,[b] including a consideration of its food plants and descriptions of different stages as well as references to literature. Still other bibliographical references have been given by Hunter.[a] This species is evidently of foreign origin and was first noticed in this country at St. Louis, Mo., by Monell in 1879.

THE MEAL SNOUT-MOTH.

(*Pyralis farinalis* L.)

During July, 1907, a colony of the larva of this beautiful pyralid moth was observed by the writer breeding in the roots of *Astragalus mollissimus* received from Hugo, Colo. Since the species is of cosmopolitan distribution and commonly found in most barns, storehouses, and even in dwellings, it can not be positively stated that it attacks loco roots in the open, but it quite likely infests the dead roots. Frequently this species breeds in clover hay, after the manner of the clover-hay worm,[c] to which it is related. As a rule the larva requires for its development a certain amount of moisture, feeding on dry material which has become heated, as in the case of stored grain or stacked hay. This species is shown natural size, the moth at *a* and the larva at *b* of figure 13. More complete accounts of the meal snout-moth are given elsewhere.[d]

FIG. 13.—Meal snout-moth (*Pyralis farinalis*): *a*, Moth; *b*, larva; *c*, chrysalis, natural size; *d*, head of larva; *e*, anal segment of larva; *f*, tip of pupa. Enlarged (author's illustration).

[a] Bul. 60, Iowa Agr. Exp. Sta., The Aphididæ of North America, 1901, p. 101.

[b] Bul. 57, Bur. Ent., U. S. Dept. Agr., pp. 26–29.

[c] *Hypsopygia* (*Asopia*) *costalis* Fab.

[d] See Yearbook U. S. Department of Agriculture for 1894, p. 286, and Farmers' Bulletin 45, pp. 10, 11.

PLANT-BUGS, LEAFHOPPERS, ETC.

Numerous plant-bugs, leafhoppers, and related insects were observed and collected at Hugo, Colo. As a considerable portion of these were in the nymph or immature stages, comparatively few were identified specifically. The list follows:

Alydus curinus Say and *A. pluto* Uhl., coreid plant-bugs bearing some relation to the squash bug, were among the number. The former has been recorded attacking Lima beans and cowpeas; hence, it is quite probable that both feed on loco and lupines, which are of the same botanical family.

Dasycoris humilis Uhl., another coreid of unknown habits.

Geocoris griseus Dall., a plant-bug of the family Lygæidæ.

Hadronema militaris Uhl., a small capsid or leaf-bug. It infests Amaranthus and beets. Probably accidental.

Stiphrosoma atrata Uhl., also a capsid, of unknown habits.

Philænus bilineatus Say, a cercopid leafhopper which probably feeds on grasses.

Deltocephalus flexulosus Ball, a jassid leafhopper.

Bruchomorpha dorsata Fitch, a fulgorid.

Nabis ferus L., a predatory form. It doubtless destroys many of the other bugs, especially in their immature stages.

MISCELLANEOUS INSECTS.

Agromyza aneiventris Fallen, a small fly, was reared from pupæ at the roots of Aragallus from Flagstaff, Ariz., received in April, 1907, from Mr. Geo. Hochderffer. We have office records of the rearing of this species from the roots of clover and from larvæ found in burrows in the stems of Ambrosia. The fly was reared by the writer from mines in garden peas collected at Washington, D. C., August 10, 1904. The insects issued July 30. Pea leaves are, in fact, quite often infested by this miner.

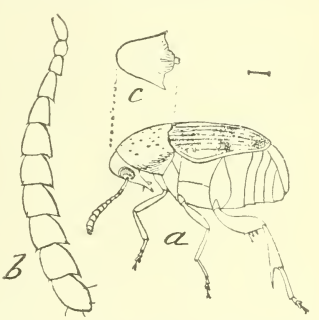

FIG. 14.—*Bruchus obsoletus*: *a*, Beetle; *b*, antenna; *c*, prothorax. *a*, *c*, Much enlarged; *b*, more enlarged. (From Riley.)

Unknown leaf-beetle.—December 14, 1901, Mr. D. P. Marum, Woodward, Okla., wrote of an insect which fed upon the leaves of *Astragalus mollissimus*. During April of that year he noticed that a few stems in each hill of loco were stripped of leaves, and found on the plants a small beetle which he believed to be a lady-bird, although it did not have the bright spots known to be present on Coccinellidæ inhabiting that region.

Bruchus obsoletus Say (fig. 14) was stated by its describer to have been found on a species of Astragalus, but recent researches show that the plant in question was a related one, the goats' rue, *Cracca* (*Tephrosia*) *virginica*.[a]

Bruchus aurcolus Horn.—Recorded as occurring on the flowers of Astragalus in Owens Valley, Cal. (Insect Life, Vol. V., pp. 166, 167).

Unknown hymenopterous gall.—Among other material collected at Hugo, Colo., were stems of *Aragallus lamberti* containing elongated fusiform galls one-half to one inch in length and about one-third that in width. Each of these contained a single large hymenopterous larva; these, however, were not reared.

[a] An illustration of this insect and its food plant were furnished in the Annual Report of the Department of Agriculture for 1892, p. 172, Pl. VII.

Rusticus (*Lycæna*) *acmon* Doubl. & Hew. This very pretty blue butterfly was reared from *Astragalus mollissimus* from Hugo, Colo., the adult issuing July 20, 1906. Nothing has been published in regard to the natural habits of this species, and it is not known if it plays any important part in the reduction of the loco weeds.

Grasshoppers and related insects were collected in some numbers at Hugo, Colo., on *Aragallus lamberti*. They were mostly in the nymph condition and therefore could not be readily identified. There were two species of grasshoppers (*Melanoplus* spp.), each occurring in about equal numbers, and a smaller grasshopper (*Opeia obscura* Scudd.), a walking stick (*Parabacillus coloradus* Scudd.) and a tree-cricket (*Œcanthus* sp.). Probably none of these accomplishes much in the line of defoliation of the loco with the exception of the two Melanopli, which are allied to the pernicious Rocky mountain locust.

Aphiochæta pygmæa Zett.—This small fly, which belongs to the Phoridæ, was reared from *Astragalus mollissimus*, from Hugo, Colo., July, 1906, from roots in which other species were breeding. This is a European species known from Texas westward to California.

In the compilation of the above list the writer is indebted to Mr. D. W. Coquillett for assistance in identifying some of the Diptera mentioned, to Mr. Otto Heidemann for the identifications of the plant-bugs, leafhoppers, etc., and to Mr. A. N. Caudell for naming the grasshoppers and related insects.

O

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L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE GREENHOUSE THRIPS.

BY

H. M. RUSSELL,
Agent and Expert.

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U. S. D. A., B. E. Bul. 64, Part VI. Issued August 4, 1909.

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THE GREENHOUSE THRIPS.

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INTRODUCTION.

This insect has been known since 1833 to have been the cause of much injury to greenhouse plants; but its life history has never been fully worked out.[a] The writer, while engaged in field work in the State of Florida during 1907, had his attention called to a "diseased" condition of crotons in one of the greenhouses at Orlando. This condition was found to be caused by the extreme abundance of a species of thrips feeding on the foliage. Specimens of the adult were sent to Dr. W. E. Hinds, who determined them to be *Heliothrips hæmorrhoidalis* Bouché. While working under the direction of Dr. F. H. Chittenden during the winter of 1907–8, the writer made a study of this insect's life history and the means by which it might be controlled.

HISTORY.

The species was first described by Bouché,[1] in 1833, as *Thrips hæmorrhoidalis* from specimens taken in a greenhouse in Europe. At that time he wrote that he believed the native land of the species to be America. That this supposition was correct appears evident at the present time.

Packard,[10] writing in 1870, described this species for the first time from this country. He wrote: "This is one of the greatest pests in our hothouses. It is the *Heliothrips hæmorrhoidalis* of Burmeister." Packard called it the greenhouse thrips and gave a meager description of the larva and adult, and an illustration of the latter, but neither descriptions nor drawing are exact enough to identify specimens. He furnished a list of food plants, a description of injury, and recommended washing plants with soapsuds as a remedy.

[a] The external and internal anatomy of this insect has been fully worked out by several European entomologists, while others have made incomplete studies of the life history on the Continent.

Under the name *Thrips adonidum*, A. J. Cook,[11] writing of this species, in 1874, said: "Around Detroit, here at Adrian, and in our southern counties they are likewise a serious pest."

In 1882 Mr. Th. Pergande[13] recorded this insect as taken out of doors at Washington, D. C., on apple late in November. J. A. Lintner,[15] in 1885, on this authority, lists it as an insect affecting the apple.

Nothing more was written about this species in this country until 1896, when G. C. Davis[21] wrote of "a black species, *Heliothrips hæmorrhoidalis*, which we have found most common on croton plants. As far as noticed its work is confined to the underside of the leaves, where the spots are eaten, so that the work clearly resembles that of the red spider."

Dr. F. H. Chittenden,[24] in 1902, predicted that this species, which he called the "greenhouse thrips," would probably increase in numbers and destructiveness with time.

Hinds[25] wrote of this insect the same year: "It has been very injurious in some places." He also added that it was called the "black fly" in Germany and that its life history was unknown.

RECENT RECORDS.

This species, determined by Mr. Pergande, was sent in to the Bureau of Entomology, January 8, 1908, by Mr. P. J. Wester, of Miami, Fla., who collected it on mango (*Mangifera indica*). He wrote: "It has never appeared to do serious damage until this year." Mr. I. J. Condit, a collaborator of this bureau, at San Luis Obispo, Cal., reported it injurious in a greenhouse at that place in September, 1908, and again reported it on November 2, 1908, as injurious to ornamentals in one of the parks at Santa Barbara, Cal.

NATURE AND EXTENT OF INJURY.

The damage caused by the greenhouse thrips is confined to the foliage of ornamental plants entirely, in so far as the author is aware, for he knows of no recorded injury to the blossoms of plants nor has he noticed any. Injury effected by the thrips is due to the method of feeding on the plants. Adults and larvæ both obtain their food by puncturing the epidermis of the leaf with their sharp mouth-parts,[a] and after lacerating the tissue they suck out tissue and plant juices at the point of attack. The insects then attack the leaf in a new place, so that in time it becomes full of tiny, pale-colored spots where the tissue and chlorophyll have been extracted.

In the case of croton plants, upon which this insect was studied, injury was noticed first on the older leaves and gradually, as these became badly infested, the injury spread until the young leaves were

[a] For structure of mouth-parts see "The Pear Thrips," by Dudley Moulton, Bul. 68, Part I, Bur. Ent., U. S. Dept. Agr., pp. 2–3, 1907.

attacked, soon after unfolding. The infested leaves first showed injury on the underside, where the surface appeared full of minute white spots. As attack continued, these spots became more numerous and united, forming blotches where the leaf was devoid of tissue. The injury then became apparent from the upper side, as the surface developed a twisted and distorted aspect between the lateral veins, and was finally evidenced by wilted and dead areas around the edges of the leaf. In severe attacks the insects spread to the upper surface of the leaves, and in a short time this as well as the underside is nearly devoid of color. Both surfaces become thickly covered with minute drops of reddish fluid voided by the thrips, which gradually change to black. As the attack continues, the leaves become limp and yellow and eventually drop off, so that plants that were not treated to prevent injury in many cases lost their entire foliage. The injury is similar on other ornamentals.

This insect injures plants in two ways: First, it causes a serious drain on the vitality of the plant from the feeding of thousands of thrips, so that the growth is seriously checked and in neglected cases would cause the death of the plant. Secondly, it destroys the beauty of the plants for ornament by despoiling them of their foliage.

ORIGIN AND DISTRIBUTION.

Although this insect was first described from Europe and is there widely distributed, it is without doubt indigenous to tropical America. Pergande[19] writes that this insect was "probably introduced with ornamental plants from the warmer regions of America;" and that it "is found upon wild and cultivated plants in Brazil." Franklin[27] records it in Barbados as follows: "This species is found in the open in St. Vincent and Barbados. It is evidently a tropical species." This insect has been collected at Miami, Fla., on plants growing in the open in midwinter. Moulton[26] says, "out of doors it feeds and becomes very destructive to Laurestinas." Mr. Condit, writing of this species from Santa Barbara, Cal., November 2, 1908, said that it was doing considerable damage to ornamentals in one of the parks.

These records of occurrences at several localities in the Tropical and Lower Austral life zones of this country point strongly to tropical America as its original home. This is further strengthened because of its well-known habit of living in greenhouses, in many localities, upon exotic plants from the Tropics. From this habit it has become widely distributed in Europe and North America. In Europe, Walker and Cameron record it from several places in England, Bouché and others from Germany, Heeger and Löw from Vienna, and Reuter from Finland. It has also been recorded from France and Italy.

In this country it has been recorded from Massachusetts, from several places in Michigan, and from Washington, D. C., Florida, and

California. It has been collected in Iowa and Pennsylvania and recently in the Barbados and the island of St. Vincent.

Because of the fact that it has been collected in such widely distant places in all sections of the country, we can safely say that *Heliothrips hæmorrhoidalis* is generally distributed in greenhouses throughout the United States.

DESCRIPTION.

Heliothrips hæmorrhoidalis belongs to the family Thripidæ, the genus being characterized by having antennæ with 8 segments and the body with a markedly reticulated surface. This is especially

FIG. 15.—Greenhouse thrips (*Heliothrips hæmorrhoidalis*): Adult female, enlarged about 50 diameters and greatly enlarged drawing of antenna underneath. (Original.)

pronounced on the head and thorax. The legs are unarmed and the wings are characterized by having the fore-wings broad at the base, with 2 longitudinal veins.

The adult (fig. 15).—When the adult first emerges the abdomen is pale yellow, with the head and thorax darker, and the antennæ, legs and wings appearing white. In the course of several hours, however, the insect becomes fully colored. The head and thorax are then dark brown, the abdomen yellowish brown, fading at the apex to brownish-yellow. In the female the antennæ are twice as long as

the head. The total length is about 1.25 mm. and the greatest width, across the mesothorax, is about 0.30 mm.[a]

The male has not been described, and this species is without question parthenogenetic for many generations.

The egg.—The egg (fig. 16,*a*) is bean-shaped, 0.296 mm. in length and 0.088 mm. in width, very delicate, with a thin shell, and colorless. Eggs are laid in the leaf tissue of the host plant, generally on the underside.

The larva, first stage (fig. 16, *b*).—[Description made while larva was very young and before it had commenced to feed on the plant.] Length, 0.31 mm.; width of mesothorax, 0.10 mm. General shape fusiform; antennæ, head, and legs very large in proportion to the rest of the body. Color translucent white. Head large, quadrate; eyes reddish, ocelli absent. Antennæ 0.16 mm. in length; 7-segmented;[b] basal segment cylindrical, short, with spine on inner side; second segment twice as long as basal one and not as wide, with 4 or 5 spines; third pedunculate, ringed, as long as segments 1 and 2 combined, 2 long spines near tip of segment; fourth pedunculate, nearly twice as long as third, tip more slender than third, ringed, a number of prominent spines near tip; fifth, sixth, and seventh slender, equal in length, and together equaling the length of the fourth, each with one or two small spines near the tip. Legs translucent white, long. Abdomen tapering posteriorly; with 10 segments, the first 8 nearly equal in length, ninth and tenth somewhat longer than others. Each abdominal segment with longitudinal rows of setæ, the ninth with 2 and tenth with 4 spines that are three or four times the length of the setæ.

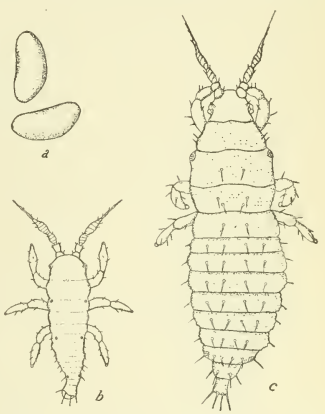

FIG. 16.—Greenhouse thrips: *a*, Egg; *b*, larva, first stage; *c*, larva, full grown. All enlarged about 40 diameters. (Original.)

The larva, second stage.—Length, 0.90 to 0.97 mm.; width of mesothorax, 0.22 to 0.23 mm.; shape about same as in first stage; body long, cylindrical, sides nearly parallel until fifth abdominal segment, where they begin to taper to blunt point. Color of thorax and abdomen slightly yellowish, last two segments of abdomen translucent white; alimentary tract plainly indicated by the brownish color given to it by inclosed food; this extends from the metathorax to the sixth abdominal segment. Surface of the body covered with minute granulations. Head quadrate, but with notch behind the eyes on each side; eyes reddish, ocelli absent. Antennæ 7-segmented, third and fourth distinctly spindle-shaped and annulated, fifth and sixth slightly annulated, and together with seventh segment quite slender. Legs translucent white. Abdomen 0.50 mm. in length, fusiform, ovipositor not formed; segments with rows of fine setæ, similar to those in adult, increasing in length toward posterior end, ninth and tenth segments equal in length (0.059 mm.).

The young nymph or prepupa (fig. 17, at left).—Length, 1.184 mm.; width of mesothorax, 0.3404 mm. Shape similar to adult. Head, length, 0.148 mm.; width at eyes, 0.1628 mm. Head translucent white, vertex slightly yellowish, ocelli absent, head

[a] For a full characterization of the genus and of the species see Hinds's Monograph of the Thysanoptera, pp. 168–170.

[b] After careful search the writer has been able to make out what he considers 7 segments in the antennæ.

deeply notched behind eyes; eyes red, made up of a few large facets, surface faintly reticulated; head rounded in front; a pair of setæ over rear angle of eyes, another pair in front of the eyes, and a third over the antennæ. Antennæ translucent, extending forward about twice the length of the head and composed of 7 segments; first segment cylindrical, broader than long; second cylindrical, nearly twice as long as segment 1 and not so broad; third longer than second, base constricted but not pedunculate, and with constriction at third and two-thirds length from base, so that it appears to be made up of 3 segments; fourth spindle-shaped, about as long as third; 5, 6, and 7 short and slender and not very clearly defined. Segments bear few spines on sides.

Prothorax nearly one-half again as wide as long, sides rounded, posterior edge broadest, semitranslucent white to faint yellow, a few prominent setæ around edges. Mesothorax with prominent rounded angles, translucent white to faint yellow, surface faintly reticulated, wing-cases translucent white, distinct from each other, those of fore-wings extending to second abdominal segment and those of hind-wings extending to middle of second abdominal segment. Legs translucent white to faint yellow, strong. Abdomen shaped as in adult, white to faint yellow, last few segments translucent, eight rows of setæ in pairs, increasing in length from anterior to posterior end. Length of abdomen, 0.5956 mm.

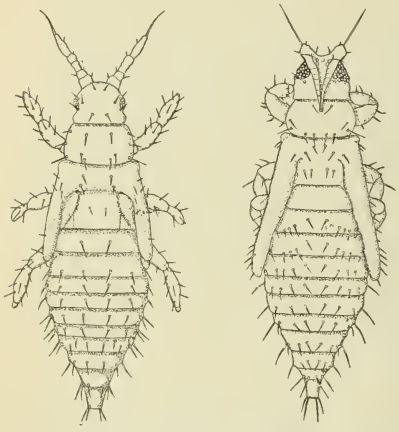

FIG. 17.—Greenhouse thrips: Prepupa on the left and pupa on the right. Enlarged about 40 diameters. (Original.)

The full-grown nymph or pupa (fig. 17, at right).—Length, 1.25 mm.; width at mesothoracic angles, 0.2812 mm. Shape similar to that of adult. Color translucent white to slightly yellowish. Head, length, 0.1628 mm.; width, 0.1924 mm.; translucent white, distinctly reticulated, eyes dark red, larger than in prepupal stage, facets large. Three ocelli present in close triangle between eyes, color chitinous yellow. Antennæ laid backward on head and reaching to near middle of prothorax, segments indistinct, translucent white. Segments 1 and 2 projecting in front of the head and 2 with a long spine extending forward, 0.1332 mm. in length. Thorax plainly reticulated, translucent white to faint yellow. Prothorax more than twice as broad as long. Wing cases 0.4736 mm. long, extending to near middle of fifth abdominal segment, translucent white to faint yellow. Length from head to end of wing-pads, 0.6512 mm. Legs translucent white to pearly white. Abdomen broader and shorter than in adult, contracted, but of same general shape, surface plainly reticulated, setæ well developed, the longest ones at posterior end. Length of abdomen, 0.6956 mm.; width, 0.3552 mm.; length of posterior setæ, 0.0888 mm.

HABITS OF THE ADULT.

After emerging from the pupæ, the mature thrips feed on the underside of the leaves for several weeks. They are not, as a rule, as abundant on the upper surface. One plant, on which there were about 150 adults, had only 3 or 4 of this number feeding on the upper surface of the foliage.

Adults walk over the leaf quite rapidly, and if disturbed they raise the tip of the abdomen and move rapidly away, walking in any direction. In a few cases they have been observed to jump when dis-

turbed, but generally they simply move rapidly. The writer has never observed adults in flight, but that they do fly is certain, as he has found that plants free from thrips and at a distance from infested plants after a time will become infested by adults. As the study of the life history of this species was carried on in an unheated greenhouse with low temperature, it is quite possible that the adults were rendered sluggish. It seems strange that the writer has not observed their flight, for in studying this thrips he has examined a large number on plants and has purposely disturbed them to induce flight. Adults often remain motionless for long periods, and in such cases rest close to the veins of the leaf.

The eggs are laid singly in the tissues of the leaf, the female first making an incision with her ovipositor and then pushing the egg into the incision. She probably lays only 1 or 2 eggs in a day, as the eggs are large and the ovaries will hold only a few matured eggs at one time. One female examined had 6 eggs partly formed in her ovaries and 3 of these were quite small. As the leaves become exhausted from the feeding of larvæ and adults, the latter leave them and oviposit in fresh young leaves, so that in time the exhausted leaves are deserted and fall off and gradually the remainder of the plant becomes infested.

HABITS OF THE LARVÆ.

On March 5 larvæ were observed hatching from the eggs about 10 a. m. In all cases where larvæ emerged the leaf was marked by a dark spot and the surface was slightly swollen.

When first observed the head of the larva was projecting slightly out of a slit in the leaf epidermis, probably the same one that was made in depositing the egg, and the light red eyes were very conspicuous. Little by little the body is worked more and more out of the opening, and as it projects in the air, working vigorously back and forth, with its limbs folded against the body and invisible, it has the appearance of a minute worm in motion. When all but the tip of the abdomen is free the tiny larva remains quiet for a very short time, then one by one, beginning with the antennæ, but the legs in no regular order, the appendages unfold. The larva moves them around freely for a time and then, bending over, grasps the leaf surface and commences to pull, in an effort to free the end of the abdomen. After considerable work the larva frees itself and after a short rest moves around in search of a place to feed. Some only travel a few inches, others travel over a considerable portion of the leaf surface before settling down to feed. The time required for the larva to emerge varies from 6 to 12 minutes.

As a rule the larvæ are found on the underside of the leaves, but when crowded, as in severe infestations, they attack the upper surface.

While they will feed anywhere on the leaf, in many cases they will cluster together in colonies between two veins of the leaf. In one case observed by the author a number of larvæ hatched from eggs on one edge of the leaf and the next day were all feeding together on the opposite edge. In another case a colony of 85 larvæ was observed collected in a circle between two veins near the edge of the leaf. Many of the larvæ in this colony were moving around, but would not separate from the colony.

The larvæ when first hatched are minute and colorless, but as soon as they begin feeding the alimentary tract becomes plainly marked from the dark reddish fluid contained in it. This fluid is excreted and collects in globules on the tip of the abdomen, being held in place by the terminal setæ. The tip of the abdomen is elevated, and it is an interesting sight to see numbers of these larvæ moving over the leaf with globules of red liquid suspended in the air on the tips of the abdomen. When disturbed they become excited and move around rapidly, jerking the abdomen from side to side. The globule of liquid gradually increases in size until it is too large to carry, and is then left on the surface of the leaf, where it dries as a small reddish spot.

As long as the food supply in the leaf is fresh and abundant these arvæ will remain on it, and thus the number becomes very large. One leaf was found with about 250 larvæ, besides a number of pupæ and adults. If disturbed, or if the leaf is beginning to wilt and lose its vitality, the larvæ become restless, separate, and move around over the leaf in search of fresh food, but eventually many will collect again in colonies. They feed unprotected on the leaf, as far as their own efforts are concerned, but in many cases they secrete themselves under a slight web made by red spiders and are protected by it. Upon leaves exposed in part to sunlight the larvæ seek that part of the leaf which is the least exposed. They molt unprotected in the midst of the feeding colony. These larvæ are delicate little creatures, and if for any reason they are knocked from the plant most of them soon die, not being able to travel far in returning to the food plant.

HABITS OF THE PREPUPA AND PUPA.

The larvæ change to prepupæ in the midst of the feeding colony without seeking protected quarters, but nearly always on the underside of the leaf. The prepupæ move around a little on the underside of the leaf and generally are clustered in groups of from 4 to 10 prepupæ and pupæ. In many cases they are under the web of red spiders, but if no red spiders have been on the plant they are then unprotected.

The pupæ are associated with the prepupæ, but do not move about unless disturbed. Not only are the prepupæ more active than the pupæ, but they carry the antennæ in front of the head and frequently move them, while the pupæ have the antennæ laid back on the head and motionless. Neither prepupæ nor pupæ take any nourishment.

FOOD PLANTS.[a]

Heliothrips hæmorrhoidalis feeds on a large number of ornamental plants. In this country it has been recorded as feeding on the following: Liliaceous plants, azalia, *Pellea hastata*, aspidium, crotons, dahlias, phlox, verbena, pink, ferns, vines, cherry laurel, lauristina, palms, ficus, and fuchsia.

This year this thrips damaged the mango (*Mangifera indica*) at Miami, Fla., and was recorded [27] from St. Vincent and the Barbados Islands on cacao, kola, and the date palm. In Europe the following list includes most of the ornamentals preyed upon by this thrips: Ærides, azalia, begonia, camarotes, catleyia, crinums, dendrobuim, eucharis, ficus, grape, lælia, lefortia, marcintacia, pancratium, phalenopsis, and viburnum.

LIFE HISTORY.

In order to study the life history of this insect, solitary females were put on isolated plants that were previously uninfested and carefully watched. An attempt to study isolated females, in small vials with bits of leaves, failed of results and after 2 weeks was discontinued.

Life cycle.—The life cycle, as detailed, is probably very near the maximum length, as the studies were conducted with the temperature of the house quite low, frequently falling to 50° F. at night. With these conditions the length of the egg stage is about 8 days, but possibly in a well-heated greenhouse this would be cut almost in half. The larvæ molt twice, the last time transforming to prepupæ, and during the cool weather require from 16 to 20 days to obtain full growth. The prepupal period is of short duration, occupying only from 10 to 15 hours, while the pupal period is from 4 to 5 days. This gives a total of 33 days as a maximum, and with favorable conditions this is probably reduced to 20 days or less.

Longevity.—The greenhouse thrips, for such a minute insect, has quite an extended duration of life and evidently feeds on the leaves for a number of days before starting egg-deposition. In one case ob-

[a] Since the above was submitted for publication some new food plants for this species have been reported. Dr. E. A. Back found it feeding on maples at Orlando, Fla., and on alligator pear (*Persea gratissima*). The fact that this insect feeds on the mango and alligator pear serves to indicate that at some time in the future it may be of great importance in Florida, as both are valuable fruits in that State.

served, no larvæ hatched until 19 days after the female was placed on a plant. This insect was about 1 day from the pupa when placed on the plant. Another female was observed for 4 weeks, when she disappeared, quite probably dying of old age. Probably this thrips lays from 10 to 20 eggs during her lifetime. The writer observed 10 larvæ on 1 plant with a single adult, and possibly some were killed by mites, etc.

Generations.—In greenhouses this insect is active during the entire year, so that the number of generations is quite large. Taking the maximum life cycle, this thrips might produce as many as 12 generations a year, provided that the species breeds continuously and conditions are favorable to rapid growth.

NATURAL CONTROL.

Rain.—In its native home this thrips is probably kept under control by frequent rains. At Miami, Fla., where hundreds of crotons are planted on hotel and private grounds, the author could find no traces of injury and collected only 1 adult. Crotons that were badly infested by this insect, kept in a greenhouse at Orlando, Fla., during the winter of 1907, were placed outside in June and by the end of the summer it was almost impossible to find specimens of the thrips on them. In times of drought this insect may increase in such numbers as to cause serious injury where it occurs in the open.

Natural enemies.—Frequently a mite is found on plants infested with the greenhouse thrips. On a few occasions the author has found thrips with one of these mites fastened to its dorsum. Specimens of this predaceous enemy were determined by Mr. Nathan Banks as *Lælaps macropilis* Bks.

ARTIFICIAL CONTROL.

EXPERIMENTS WITH REMEDIES.

FUMIGATION EXPERIMENTS.

A series of fumigation experiments was conducted against this insect in its occurrence on croton at Orlando, Fla. All were made in a small, fairly tight room, containing 660 cubic feet.

Experiment No. 1.—April 27, 1908, at 4 p. m., a plant was fumigated all night with one sheet of nico fume. It was a cloudy, cool day, just after a rain, and a good breeze was blowing. On opening the room at 8.15 a. m. there was quite a pronounced odor of nicotine.

April 28, the paper below the plant was covered with this insect in all stages, and many were also found on the plant.

Result of the fumigation, counting the thrips on the plant:

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	109	30	436	575
Alive	10	26	10	46
Per cent killed	91.6	53	97.6	92+

May 2, the plant was in fine condition and uninjured. About 10 live adults remained. No live larvæ were seen, but the leaves were covered with hundreds of dead ones.

Experiment No. 2.—May 16, at 5.45 p. m., a plant was fumigated overnight with one-half sheet of nico-fume paper. At 5.45 p. m. it was dark from rain clouds.

May 17, the plant was uninjured. Red spiders and mealy bugs were alive. Few thrips were on the plant.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	2	5	10	17
Alive	0	13	0	13
Per cent killed	100	27+	100	56⅔

Experiment No. 3.—April 28, at 5.15 p. m., fumigated a plant overnight with one sheet of aphicide. The sky was cloudy and there was a strong breeze. The plant had a few thrips on it.

April 29, when examined at 8.45 a. m., the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	30	1	6	37
Alive	3	0	2	5
Per cent killed	90	100	75	88+

May 2, the plant was in fine condition.

Experiment No. 4.—May 24, at 7 p. m., fumigated a plant with one sheet of aphicide. There was a strong breeze.

May 25, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	3	10	67	80
Alive	0	2	0	2
Per cent killed	100	83⅓	100	97+

Experiment No. 5.—May 22, at 6 p. m., fumigated a plant overnight with one-half sheet of aphicide. There was a strong breeze.

May 23, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	6	15	31	52
Alive	2	21	11	34
Per cent killed	75	41⅔	73.8	60.4+

Experiment No. 6.—April 30, at 8.30 a. m., a plant was fumigated with one sheet of aphis punk (=2 sheets of nico fume or aphicide) all day; cloudy. Toward the end of the fumigation the punk began to burn in strips, so it was not all consumed. It gave a very dense smoke. The room was opened late in the afternoon.

May 1, the plants were uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	7	0	3	10
Alive	14	11	18	43
Per cent killed	33⅓	0	14.2	18.8

May 2, live thrips were abundant on the plants.

Experiment No. 7.—April 30, fumigated with one-half sheet of aphis punk (equal to 1 sheet of other kinds), but as it did not burn up, the house was opened at 5.30 p. m. and a fresh piece put in. The fumigation lasted all night. This piece also burned in strips and a third was not consumed.

May 1, the plants were uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	0	2	3	5
Alive	11	13	15	39
Per cent killed	0	13½	16⅔	11+

It seems that the thrips that drop to the ground have a better chance to recover than those on the plant.

Experiment No. 8.—May 1, at 5.15 p. m., fumigated all night with one-half sheet of aphis punk (fresh box from the factory). This was entirely consumed and the room well filled with smoke.

May 2, the plants were uninjured; red spiders were alive.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	68	1	42	111
Alive	4	24	1	29
Per cent killed	94.4	5	97+	86.4

Experiment No. 9.—May 26, at 7 p. m., fumigated with one-half sheet of aphis punk (fresh box). Fumigation lasted all night. The sky was cloudy.

May 27, the plant was uninjured. The condition of the thrips was as follows:

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	7	2	2	11
Alive	0	7	0	7
Per cent killed	100	22+	100	61⅛

Experiment No. 10.—May 20, at 5.50 p. m., fumigated with nicofume liquid (1 tablespoonful = ½ ounce + 1 ounce water, vaporized over an alcohol lamp). The sky was partly cloudy. Sprinkled the plant with water.

The vapor rose slowly until 6 p. m., when small flies on the window began to drop. House flies were still flying around the room at 6.15 p. m., when the liquid was all evaporated.

May 21, the plant was uninjured. Red spiders were apparently all alive. A very careful examination of the plant failed to show a live thrips.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	74	12	8	94
Alive	0	0	0	0
Per cent killed	100	100	100	100

Experiment No. 11.—May 27, at 3.50 p. m., fumigated with nicofume liquid (½ tablespoonful to 2 tablespoonfuls of water, vaporized). Sky clouded, breeze strong.

May 28, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	3	2	1	6
Alive	0	2	0	2
Per cent killed	100	50	100	75

Experiment No. 12.—May 21, at 6 p. m., fumigated with rose-leaf insecticide (29 c. c. + 25 c. c. water, vaporized over an alcohol lamp). The sky was cloudy, with rain falling.

May 22, the plants were apparently uninjured. Red spiders were alive.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	7	2	4	13
Alive	0	0	0	0
Per cent killed	100	100	100	100

Experiment No. 13.—May 18, fumigated with potassium cyanid (0.00⅔ gram per cubic foot. In 660 cubic feet used 4.4 grams potassium cyanid, 7.92 c. c. sulphuric acid, and 15 c. c. water). Time, 5.30 p. m. Sky clouded; temperature 82° F; breeze strong; length of fumigation, overnight.

May 19, the plant was uninjured.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	8	0	1	9
Alive	2	17	54	73
Per cent killed	80	0	1.8	10.9

This strength was entirely too weak.

Experiment No. 14.—May 19 fumigated with potassium cyanid (0.02 gram per cubic foot. In room used 13.2 grams potassium cyanid, 26.8 c. c. sulphuric acid, and 53.6 c. c. water). Time, 6 p. m. Length of fumigation, all night. Temperature, 78° F.; breeze strong.

May 20, the plants were uninjured. Flies and bees in the room were all dead. Red spiders were alive. The thrips were all dead.

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	3	10	28	41
Alive	0	0	0	0
Per cent killed	100	100	100	100

May 25, the plant was uninjured.

SPRAYING EXPERIMENTS.

Experiment No. 15.—February 25, sprayed very thoroughly with rose-leaf insecticide (1 part to 48 parts water) a large croton infested with this thrips in all stages. Gave the upper and under sides a very thorough spraying so as to cover entirely the surface and be sure to hit nearly all of the thrips. The spraying was done in the afternoon when the house became shaded from the sun. A fine spray from a small hand pump, common in greenhouses, was used.

February 26, examined the plant at 9.30 a. m. and find results as follows:

	Adults.	Pupæ.	Larvæ.	All forms.
Dead	34	5	5	44
Alive	1	2	2	5
Per cent killed	97.1	71.4	71.4	90

May 12, 1908, this plant had then a number of young thrips upon it again and a lot of adults that had flown onto it.

Experiment No. 16.—February 20, 1908, sprayed with cold water. Took hose and washed off all of the plants in the greenhouse with cold water. The next morning found the adults still common and also many larvæ on the crotons, but many leaves badly infested before washing were then entirely free from them. Probably the spraying with cold water washed away and killed 40 to 50 per cent of young thrips.

SUMMARY OF EXPERIMENTS.

The fumigation and spraying experiments in the control of the greenhouse thrips may be summarized as follows:

No. of experiment.	Date.	Method.	Material.	Amount per 660 cubic feet.	Per cent killed.	Injury to plant.	Status of red spider after treatment.
1	Apr. 27	Fumigation	Nico-fume paper.	1 sheet	92	None	Alive.
2	May 16	do	do	½ sheet	56.6	do	Do.
3	Apr. 28	do	Aphicide	1 sheet	88	do	Do.
4	May 24	do	do	do	97	do	Do.
5	May 22	do	do	½ sheet	60.4	do	Do.
6	Apr. 30	do	Aphis punk	1 sheet	18.8	do	Do.
7	do	do	do	½ sheet	11+	do	Do.
8	May 1	do	do	do	86.4	do	Do.
9	May 26	do	do	do	61+	do	Do.
10	May 20	do	Nico-fume liquid.	½ ounce	100	do	Do.
11	May 27	do	do	¼ ounce	75	do	Do.
12	May 21	do	Rose-leaf insecticide.	29 c. c	100	do	Do.
13	May 18	do	Potassium cyanid.	0.00½ gram per cubic foot.	10.9	do	Do.
14	May 19	do	do	0.02 gram per cubic foot.	100	do	Do.
15	Feb. 25	Spray	Rose-leaf insecticide.	1 part to 48 parts water.	90	do	Do.
16	Feb. 20	do	Water in hose	Drenching	40–50	do	Do.

REMEDIES RECOMMENDED.

For the treatment of this pest there are a number of good remedies. The question as to the best method to employ depends upon the size of the house infested and upon the experience of the person engaged in treating the insect.

Fumigation with nicotine papers.—Any of the standard fumigating papers will give good results against this pest if they are strictly fresh and kept tightly sealed. Fumigation should be done at night in a moist atmosphere and the papers should be used at the rate of about 2 sheets for every 1,000 cubic feet of space. Early in the morning the house should be opened and thoroughly aired.

Fumigation with nicotine liquid extracts.—Liquid extracts of nicotine offer one of the best methods of greenhouse fumigation and against this pest are very successful. Those made up of 40 per cent nicotine should be used at the rate of 1 ounce to every 1,000 cubic feet of space and the weaker solutions at greater strengths. The preparation should be evaporated over small lamps or stoves, and to prevent

scorching should be diluted with water, approximately two-thirds. Fumigation should be carried on at night in a moist atmosphere, and the house should remain closed all night.

Fumigation with hydrocyanic-acid gas.[a]—*When fumigating with hydrocyanic-acid gas great care should be taken, as this gas is fatal to all animal life.* The work must be conducted at night and *the plants should have dry foliage.* In treating this insect, use from 0.01 to 0.05 grams of potassium cyanid per cubic foot for from 2 hours to all night, the strength and length of exposure varying according to the tightness of the house and the kind of plants being treated, as there is considerable difference between various plants as to their resisting power to this gas.

Spraying with nicotine liquids.—Nicotine extracts diluted with water, if carefully applied to plants, will kill large numbers of the greenhouse thrips, but the great objection is that many are not hit by the spray, and therefore the plants become infested again in a short time.

Spraying with kerosene emulsion.[b]—It is quite possible that kerosene emulsion spray will be effective against the greenhouse thrips when used at the strength of 1 part of stock to 10 parts of water and it costs considerably less and is more readily obtained than the nicotine preparations. It should be very carefully prepared and used experimentally at first until the effect on the foliage of the different plants is noted. Care should also be taken to prevent a quantity of emulsion from collecting around the roots.

Water spray.—Frequent treatment with a stiff spray of water from a garden hose will tend to keep this insect down, but unless there are only a few plants it would be better to use one of the other remedies.

Any treatment for this insect should be repeated in from 7 to 10 days to destroy the young larvæ that have hatched from the eggs. This should be sufficient, but it may be best to give a third treatment in another week or two.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 64, Part VII.
L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NEW BREEDING RECORDS OF THE COFFEE-BEAN WEEVIL.

BY

E. S. TUCKER,
Special Field Agent.

ISSUED AUGUST 5, 1909.

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(*Araecerus fasciculatus* De Geer.)

By E. S. Tucker,
Special Field Agent.

INTRODUCTION.

While making field observations upon the cotton boll weevil during the past season (1908), a large plantation situated 6 miles south of Alexandria, La., was visited on September 18 and again on December 4. On my first visit at this place the overseer directed my attention to the work of strange weevils occurring in dried cornstalks in fields adjacent to cotton. Upon examination the larval and pupal stages and sometimes a few adults of the insects were found in the pith, at or close to the joints (Pl. III). These specimens were identified as the coffee-bean weevil (*Araecerus fasciculatus* De Geer) (fig. 18), and the selection of cornstalks for breeding purposes places the species on record as a new enemy to be encountered in cornfields.

NATURE OF INJURY TO CORN.

According to the statements of the overseer, the working of these weevils in cornstalks during the past year was more noticeable than in the preceding season, when he first detected the insects at work. He claimed that the attacks began in green stalks before the corn matured and thus caused stunted ears. Being a close observer, he first noticed their attacks during the last week of August, while the stalks were still fresh and sappy, although the leaves had begun to dry. These facts prove beyond question that the larvæ were hatched within living tissues of the plants. Furthermore, he expressed a firm belief that the holes made by these insects for emergence from the stalks afterwards offer a retreat for cotton boll weevils, which may enter and hibernate in the pith. His opinion in this respect was supported by the claim that he had found boll weevils in such places at the time the land was being prepared for spring planting.

In the course of such work many old cornstalks were dragged out of the dirt that had been thrown over them by means of a "middle-buster" plow used for breaking the ground during November and December; and in two or three instances, which he remembered as having occurred in February, he found stalks with boll weevils secreted in the cavities evidently formed by the stalk pests.

At the time of my first examination the emergence holes and other signs of work by *Arræcerus fasciculatus* were not visible unless the leaves were stripped from the stalks as they stood in the fields. Centers of infestation were then located in different parts of the fields by breaking open a number of stalks to ascertain the extent of depredations. As most of the ears had been gathered, inspection of the greater part of the fields was freely made and infested sections of the stalks were collected. The damaged stalks broke easily at the joints where larvæ had worked, and usually but one injured place was found on a stalk. All attacks by the weevils at this time were

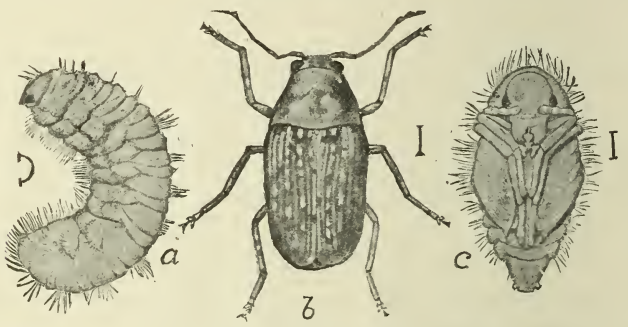
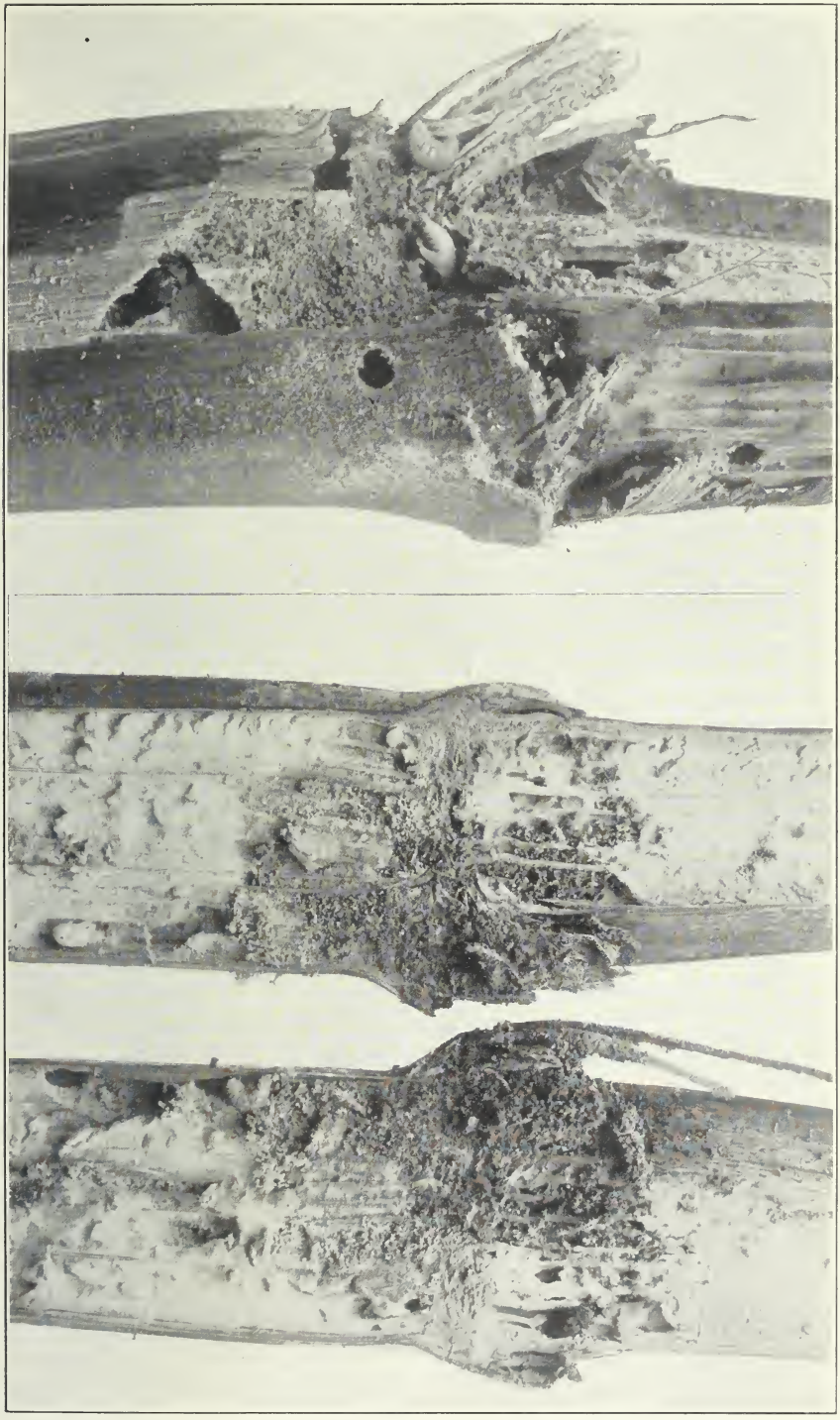


FIG. 18.—Coffee-bean weevil (*Arræcerus fasciculatus*): *a*, Larva; *b*, adult or beetle; *c*, pupa. Greatly enlarged. (From Chittenden.)

confined to the upper joints. These damaged joints varied in thickness from a little more than an inch to slightly less than one-half inch. The extra thick and hard structure of the lower joints was then thought to present unsuitable conditions for the breeding of the weevils, at least where the pith incompletely filled the stem. Further developments which were noted on my second examination showed, however, that the insects had bred extensively and worked downward into the lowest joints, their tunnels running through the pith from one joint to another. Since all stages were found again, the prospect for continual breeding of the weevils, which perhaps depends upon mild weather, seemed to be assured as long as the stalks were not destroyed. As previously observed, the effects of their work were most noticeable at the joints. The common occurrence of damaged stalks, which were readily detected on account of the emergence holes being exposed to view by reason of the partial loss of the leaves, indicated that the infestation was widespread.



WORK OF THE COFFEE-BEAN WEEVIL (ARÆCERUS FASCICULATUS) IN CORNSTALKS. (ORIGINAL.)

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NOTES ON LIFE HISTORY IN CORN.

Judging from the appearance of damaged stalks when split open, the larvæ evidently begin work at a joint and form wide cavities, mainly in a crosswise direction, as they progress into the pith. All examples of their injuries showed that irregular portions of the pithy substance, excepting most of the fibers, had been reduced to a discolored, powdery condition, which was usually more pronounced above the joint than below it. The greater part of the time necessary for the growth of the grubs is probably spent in the excavation of these spaces to satisfy their demands upon the pith as a food supply. In preparation for the pupal stage the grown or nearly grown larvæ manifest a tendency to burrow into fresh pith some distance from the area of early operations. A considerable proportion of them does this; though few grubs proceed farther than 2 inches upward or downward. These burrows run in somewhat deflective courses, but when finished always terminate just under the hard surface of the stem and afford a convenient position at the far end for each insect upon attaining maturity to gnaw its way out, as was proved in many cases by an emergence hole being already cut to afford means of escape to the tenant. Nearly every closed burrow contained either a grown larva, a pupa, or an adult. These stages commonly occurred also in or close to the large primary cavities, indicating that not all the larvæ undertake special measures for pupation away from their original place of development, though all apparently provide for facility of emergence as adults, and the greater number perhaps complete their transformations in the same relative position. In fact, the greater number of openings appearing through the surface immediately surrounding the worst damaged places close to the joints shows that emergence is most frequently effected there.

OCCURRENCE IN CHINABERRIES; PARASITES.

The further records on the habits of *Araecerus fasciculatus* are obtained from the notes on file at the laboratory of the Bureau of Entomology at Dallas, Tex., all of which pertain to the breeding of the species in berries of the chinaberry tree (*Melia azedarach*). Several larvæ and pupæ and one adult were found in the pulp of old chinaberries collected at Victoria, Tex., April 24, 1907, by Mr. R. A. Cushman. From other collections of similarly infested berries, made at the same place on May 12, by Mr. A. C. Morgan, adult weevils first emerged seven days later, and on the 27th and 28th of the same month the first rearings of parasites were recorded. These parasites represented a species which was later described by Mr. J. C. Crawford as *Cerambycobius cushmani*, and further developments not only proved it to be the most important enemy of *Araecerus fascicu-*

latus, but highly inimical to the cotton boll weevil. Numbers of these parasites, together with *Eurytoma tylodermatis* Ashm., which also attacks the boll weevil, matured during the following June and July from another lot of old berries infested by the immature stages of *Arræcerus fasciculatus*, the material having been collected by Mr. Cushman on June 11. Other species of parasites were reared from these lots, but so far remain undetermined. The latest date recorded for the emergence of weevils in confinement was July 11, but under natural conditions these insects probably breed continuously throughout the season in berries which are apt to be hanging on trees or falling from them at all times of the year.

During the past year opportunities permitted me to make personal observations upon the work of these weevils in chinaberries. While at San Augustine, Tex., on March 22, my attention was drawn to an infestation occurring in both fallen and hanging berries. Fallen berries in a soft, shriveled, or rotting condition frequently contained well advanced larval stages. Seldom were more than one or two grubs found in a berry. The larvæ in hanging berries were generally younger. Some of the hanging berries contained very small grubs, evidently newly hatched, that had scarcely begun working in the firm pulp. The falling of infested berries seemed to be induced by the softened condition resulting from the more advanced work of the larvæ, and the pupal stage must necessarily be passed in fallen berries. Collections of these berries were placed in breeding boxes, and adult weevils emerged from April 16 until June 16, but no parasites appeared, probably because of the earliness of the collection. On March 25, at Longview, Tex., the species was again taken by me, but only fallen berries were examined. A live adult was removed from one berry.

At Monroe, La., on the 21st of the same month, Mr. R. A. Cushman made an interesting find in regard to a new enemy of the coffee-bean weevil. In a number of infested berries one weevil larva was found to be attacked by a new species of mite belonging to the genus Pediculoides. This mite is also known as an enemy of boll weevil larvæ.

HABITS IN GENERAL.

Previously published records of *Arræcerus fasciculatus* show it to be a common insect in warm climates, and that it has no particular food preferences. It is as likely to be found breeding in beans or any stored dry vegetable products, including dried fruits, as in dry pithy stalks, and is commonly found breeding as a scavenger in dry decayed cotton bolls. In common with most other weevils, the adults feign death for a short time when disturbed, and then suddenly become active and seek to escape.

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A NEW ENEMY OF THE FLORIDA ORANGE.

BY

E. A. BACK, PH. D.,

Agent and Expert.

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Agent and Expert.

INTRODUCTION.

The attention of entomologists is called, for the first time, to the discovery in this country of a new species of *Aleyrodes* which attacks citrus trees. In view of the widespread havoc played among the orange groves of Florida by the citrus white-fly (*Aleyrodes citri* Riley and Howard) and the spotted-wing white-fly (*Aleyrodes nubifera* Berger), the appearance among the orange trees at Tampa of another aleyrodid which has already demonstrated itself to be of economic importance is of interest, if not, indeed, a subject for considerable concern.

During a recent examination of orange trees along several of the streets in the business section of Tampa in connection with government white-fly investigations that are being carried on in Florida by the Bureau of Entomology, the attention of the writer was attracted to dense white and grayish woolly secretions on the under surface of many leaves. At first this was supposed to be a heavy infestation of the rather scarce *Paraleyrodes perseæ* Quaintance, but on closer examination proved to be *Aleyrodes howardi* Quaintance, up to the present time known only to infest orange trees on several of the West Indian islands, especially Cuba.

INJURY AND EXTENT OF INFESTATION.

At present very little is known of the capacity for injury possessed by this aleyrodid. Mr. C. L. Marlatt, Assistant Chief of the Bureau of Entomology, found it quite abundant, locally, on several of the old orange trees at Artimisa, Cuba, but at that time (1905) noted

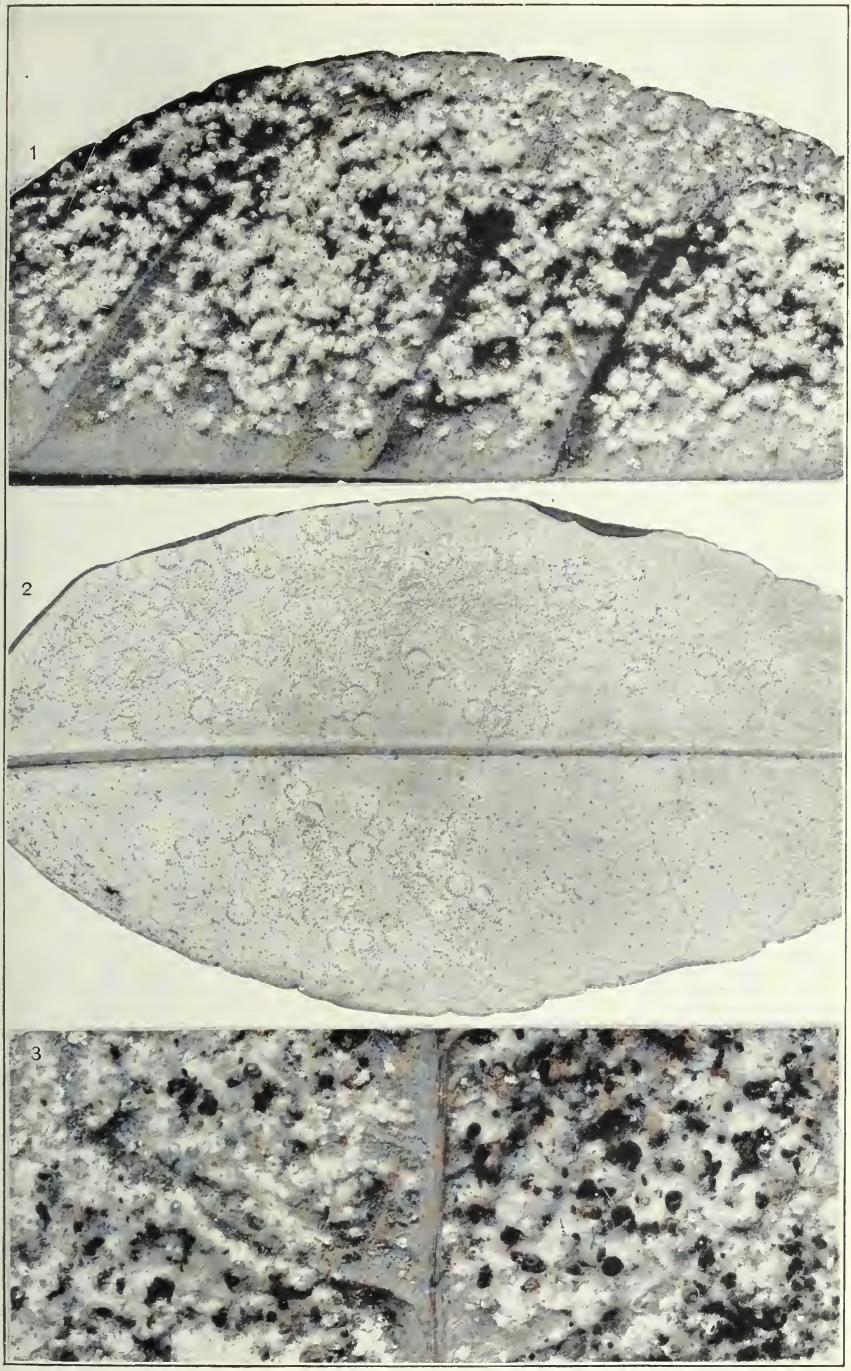
that it had spread but slightly into the surrounding younger citrus groves. When describing it for the first time Prof. A. L. Quaintance [a] stated that, judging from its abundance on leaves sent to the Bureau of Entomology from Cuba, it was a very serious pest of the Cuban orange, possibly rivaling the well-known citrus white-fly in Florida. Whatever damage it is causing in Cuba, where it may be partially held in check by parasites and predaceous enemies, it has shown itself capable of rapid multiplication and spread in its new home at Tampa. Notwithstanding the fact that it has not been observed in Florida before, although many trees now heavily infested have been under casual observation during 1907 and 1908, it has become well established over a very large portion of the city, spreading northward beyond Michigan avenue and eastward about 2 miles, into Ybor City. Orange groves in the more elevated portions of the city are thoroughly infested, hence it is safe to presume that the pest is well established in the western section of the city.

From the present infestation it appears that the insect first secured a foothold along the water front, and this points to its possible importation from Cuba. In this section neglected worthless trees along the streets and in dooryards are in many cases heavily infested. While it appears to be rivaling the citrus white-fly in the extent of its attack on some trees, it is improbable that it is capable of causing such widespread disaster; nevertheless, if it becomes abundant in a grove, it will prove a source of no little aggravation and discomfort to those working in the trees because of the large and extremely viscid drops of honeydew which collect over the bodies of the insects, and later become embedded in the copious waxen secretions.

LIFE HISTORY.

Nothing has been published regarding the life history of this aleyrodid aside from the statement made by Professor Quaintance (l. c.) that the eggs lie prostrate on the leaf, and are arranged, more or less, in circles or curves. When discovered in Tampa by the writer on November 14, 1909, adults were abundant and depositing eggs upon both new and old growth, showing the usual preference for the former, and larvæ in all stages, as well as pupæ, were numerous. Later, on December 15, Mr. S. S. Crossman found adults abundant, and examination of material at this time showed that pupæ were still maturing. The last brood of adults of this species is, therefore, on wing later in the year than that of either the citrus or spotted-wing white-fly. Adults were noted by the writer on a visit to Tampa during late January.

[a] U. S. Dept. Agr., Bur. Ent., Tech. Ser. 12, Pt. V, pp. 91–92, 1907. The more important Aleyrodidæ infesting economic plants, with description of a new species infesting the orange.



THE WOOLLY WHITE FLY (ALEYRODES HOWARDI) ON ORANGE.

Fig. 1.—Moderate infestation of leaf, showing many specimens in larval instars. Fig. 2.—Eggs on tender leaf. Fig. 3.—Heavy infestation of leaf, showing globules of honeydew embedded in woolly secretions overgrown by fungi. (Original.)

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Unless molested or crowded each female deposits her eggs in a complete circle (Pl. IV, fig. 2), she being always on the inside (fig. 19, *c*). This arrangement she effects by using her mouth parts as a pivot upon which to rotate her body. Since often as many as 3 or 4 rows of eggs are present in one circle, it is evident that the female describes several circles while ovipositing before seeking a new place. Although as few as 27 eggs have been counted in a single circle and as many as 130 in a circle of 4 rows, it is probable that the larger number does not indicate the maximum egg-laying capacity, which, in the case of *A. citri*, has been found to be 222.

The eggs are whitish when deposited but soon turn to a dark-brown or blackish color and become partially covered by waxen secretions rubbed from the bodies of the adults. They are curved, the concave side being upward (fig. 19, *a*, *b*), and in hatching the membranes rupture along the median distal half of the upper surface and do not spring back into place after the larva has escaped.

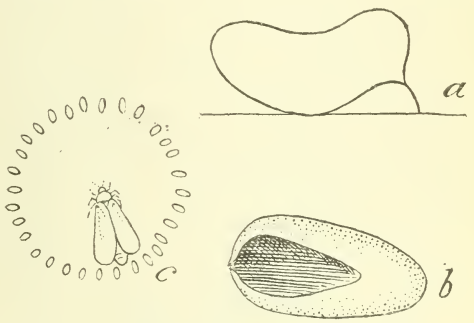

FIG. 19.—The woolly white-fly (*Aleyrodes howardi*): *a*, Egg, showing attachment to leaf; *b*, eggshell, viewed from above; *c*, female depositing eggs in a circle. *c*, Much enlarged; *a*, *b*, highly magnified. (Original.)

The larva after hatching crawls about before settling. It is yellowish, elliptical, with 9 pairs of marginal spines and 4 pairs of short, stout, dorsal spines. Soon after ceasing to crawl, it develops a short, inconspicuous, marginal wax fringe similar to that of the first instar of *A. nubifera* (fig. 20). In the second instar the marginal bristles are lost except one anterior and two posterior pairs, and the legs become unfit for locomotion as is the case with other aleyrodids. During this instar there develop 6 white abdominal cross-bands and a distinct, white, marginal fringe of wax, varying in width with age, often becoming 0.3 mm. wide; aside from these secretions, each of the dorsal spines secretes a long, outstanding waxen rod, of varying length, these rods being at all times characteristic of this instar (see fig. 21). After passing into the third instar the larva, except in point of size, assumes the appearance of the pupa; the marginal fringe and abdominal secretions found in the preceding instar remain practically the same, but these are largely or wholly concealed by the long, white, curling, and variously matted secretions which arise from along, but not on, the margin of the insect, giving to a leaf infested with this species a woolly appearance (Pl. IV, fig. 1) which, when infestation is heavy, entirely conceals the insect beneath. These threadlike secretions are often twice as long as the insect itself. At

emergence the pupa case splits at the anterior end, down both the dorsal and ventral sides along the median line, on the dorsal side splitting back to the first abdominal segment. The empty pupa case is white and delicate. The adult insect of either sex is lemon-yellow, with pure-white wings, without darker markings; the ground color of the body being partially obscured by loose particles of waxen secretions. The adult resembles closely *A. citri*, the citrus white-fly, but carries its wings farther away from the body, thus leaving more of the abdomen exposed.

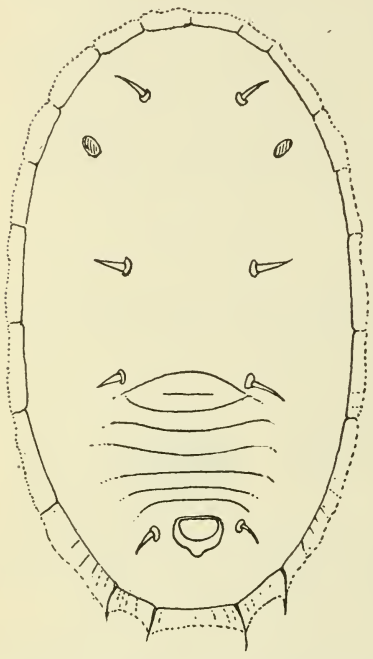

FIG. 20.—The woolly white-fly: Larva of first instar, dorsal view, showing spines and marginal wax fringe. Highly magnified. (Original.)

A very characteristic feature of this species, as compared with any of the Florida Aleyrodidæ now known to the writer, is the globule of honeydew which collects over the vasiform orifice, often becoming so large as to conceal the posterior half of the body, and resembling somewhat the secretions of the persimmon Psylla. These globules are extremely viscid and make the handling of leaves infested with this aleyrodid very disagreeable. They collect in large numbers in the waxen secretions on heavily infested leaves (Pl. IV, fig. 3) and both they and the secretions become grayish and dust-laden with age. The globules frequently become overgrown by a rank growth of greenish-brown fungus resembling the hyperparasitic species attacking the yellow white-fly fungus, *Aschersonia flavocitrina*.

DESCRIPTION.

A detailed description of *Aleyrodes howardi* follows [a]:

The egg.—Length, 0.2 mm. to 0.19 mm.; width, 0.1 mm. to 0.088 mm. Uniformly brownish in color, smooth, without reticulations or waxy secretions; curved, lying prostrate on leaf, with convex side approximating latter, attached by short stalk arising from convex surface about one-fourth distance from base to tip of egg. Eggs deposited more or less in complete circles; spaces between eggs often filled with waxy secretions rubbed from body of adults. (See fig. 19.)

[a] The original description of the pupa by Professor Quaintance has been used but amplified by the writer.

The larva, first instar.—Size about 0.26 mm. by 0.13 mm.; elliptical, yellowish-white, with 9 pairs of short marginal bristles, arranged as in figure 20, the two posterior pairs longest, the relative lengths being as follows:

Pair	1	2	3	4	5	6	7	8	9
Relative lengths	2	2.5	6	4	5	5	4	8	8

After settling, an inconspicuous, transparent, marginal wax fringe develops, but little exceeding in width the length of the marginal spines. Eyes reddish-brown, usual. Dorsum with 4 pairs of short stout spines; 1 pair cephalad and mesad of eyes, 1 pair at vasiform orifice, and 2 pairs on central region between the fifth and sixth, and sixth and seventh pairs of marginal spines, respectively. Legs and antennæ well developed, usual; vasiform orifice similar in shape to that of pupa, but without apparent strong setæ.

The larva, second instar.—Size, about 0.38 mm. by 0.22 mm. All marginal bristles lost except 2 pairs of minute bristles, one at anterior, the other at posterior end of body. Four pairs of bristles on dorsum located as in first instar, but different in that when wax secretions are removed, the first 3 anterior pairs are stout spindle-shaped (fig. 21, *a*), the fourth pair at vasiform orifice, long and slender, as in pupal stage; a fifth dorsal pair at caudal end of body but not on margin, similar to those in pupal stage. Color, brownish or black; margin with narrow white wax fringe, equaling at times 0.3 mm. Instar conspicuous because of long single, stout, outstanding waxen rods secreted by each of the spindle-shaped dorsal spines, and 6 abdominal cross bands of white waxen secretions. Insects well advanced in this instar, after the dorsal waxen rods have developed, present a profile similar to that shown in figure 21, at *b*.

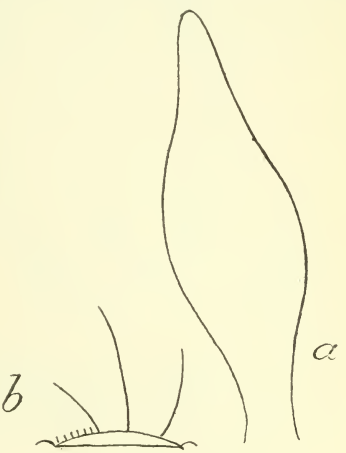

FIG. 21.—The woolly white-fly, second larval instar. *a*, Spindle-shaped spine; *b*, diagrammatic profile, showing characteristic wax secretions. Highly magnified. (Original.)

The larva, third instar.—Size, about 0.58 mm. by 0.38 mm. Except in point of size, this resembles the pupal instar in all respects. The spindle-shaped spines of the previous instar are replaced by ordinary strong bristles.

The pupa.—Size, about 0.9 by 0.55 mm., subelliptical in shape. Many specimens with more or less evident indentures on cephalo-lateral margin of case, with cephalic end obtusely pointed. Color, on leaf, under hand lens, with secretions removed, yellowish-brown varying to blackish; under transmitted light, yellowish to brownish-yellow. There is a distinct marginal rim all around, with wax tubes distinct, the incisions acute and tubes rounded distally. From margin of case all around arises a short rim of wax, composed of individual wax-threads, serrated on margin as seen under a high-power microscope. Pupa usually quite covered by a very copious secretion of whitish, curling wax-rods which is very conspicuous in badly infested leaves, quite hiding the insects beneath (Plate IV, fig. 3); these waxen filaments often much greater in length than the insect's body, spreading outward when insects are not crowded, but upward when crowded; and arising from along the outer portion of the case, but not on the margin itself from which the above-mentioned distinct waxen fringe arises. Dorsum of pupæ with many wax-secreting pores; the secretions very short, irregular upon the cephalothoracic region, and on the abdominal portion arranged in cross bands on each segment, being

most dense on the middle of the segments. Denuded of secretions, the pupa case is seen to be at first almost flat, but later becoming rather convex as the insect develops, with segments distinct.

Dorsum with pair (1) of strong setæ on first abdominal segment, a pair (2) at vasiform orifice, and a pair (3) at, but not on, caudal margin extending some distance beyond margin of case. There is also a pair of minute marginal spines (a) at the anterior end, and another (b) at the posterior end of body. The relative lengths of these spines are as follows:

Pair	1	2	3	a	b
Relative lengths	14	16	10	1.5	2.5

There is also a pair of small bristles on the venter beneath the vasiform orifice. Vasiform orifice relatively small, subcordate, the rim dark brown, from 6 to 8 strong setæ or spines arising from caudal margin; operculum largely filling orifice, the distal margin with two faint notches; lingula not distinguishable. (See fig. 22.)

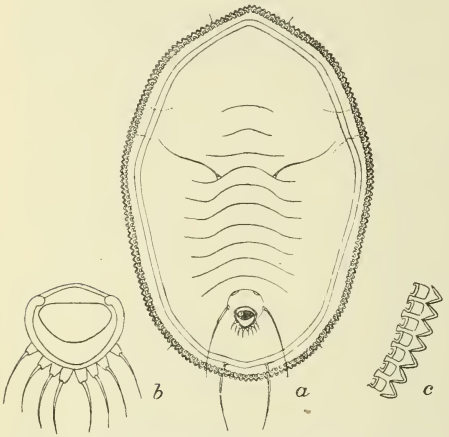

FIG. 22.—The woolly white-fly: Pupa case and details. Greatly enlarged. (From Quaintance.)

The adult.—Usual, lemon-yellow, after emergence becoming coated with white waxen secretions; wings pure white, without darker markings, held along sides of abdomen, but not meeting over the dorsum. A considerable amount of flocculent white wax is secreted, but not as copious a supply as is secreted by the adult of *P. perseæ*. In female: Length of body, 0.42 to 0.47 mm.; length of fore wing, 1.1 mm.; width of fore wing, 0.36 mm.; length of antenna, 0.31 mm.; length of hind tibia, 0.035 mm.; relative lengths of antennal segments as follows:

Segment	1	2	3	4	5	6	7	Spine.
Relative lengths	1.5	3	10	1.3	2.5	2.6	1.5	0.7

FOOD PLANTS.

The woolly white-fly infests the various species of citrus, the guava, and the mango. While found on the mango at Tampa by the writer, its presence on this plant is probably the result of accident. Mr. W. L. Tower is authority for its occurrence on guava in Porto Rico.

DISTRIBUTION.

This species occurs on several islands of the West Indies, but more especially in Cuba. It is now established at Tampa, Fla.

NATURAL ENEMIES.

While no predaceous insects are known to attack this aleyrodid, Cook and Horn[a] have reported it parasitized by the "red fungus,"

[a] Cook, M. T., and Horne, W. T., Cuban Exp. Sta. Bul. 9, p. 31, 1908.

Aschersonia aleyrodis, in Cuba, and Mr. W. L. Tower, entomologist of the Porto Rican Experiment Station, reports that in Porto Rico it is held in check by fungi (undetermined).

REMEDIES.

So far as known to the writer no remedial measures have been adopted against this pest up to the present time. Its recent discovery has not made it possible for experiments leading to its control to be concluded although such experiments are now in progress. From present indications it seems probable that this white-fly will be more easily controlled by fumigation than by spraying, inasmuch as when nearly mature it is very well protected from spray liquids by the secretions mentioned above. Present indications are that during the early larval instars it is as well controlled by spraying as are the citrus and the spotted-wing white-flies, with which it is found associated.

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L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON A COLORADO ANT.

BY
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Agent and Expert.

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SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

NOTES ON A COLORADO ANT.

(*Formica cinereorufibarbis* Forel.)

By H. O. Marsh,
Agent and Expert.

INTRODUCTION.

A medium-sized ant, known scientifically as *Formica cinereorufibarbis* Forel, is one of the most common species occurring in the vicinity of Rocky Ford, Colo. The nests which it constructs along the fences and irrigation ditches are mounded up very little or not at all, but often cover a considerable area. Sometimes these nests are 3 or 4 feet in length by 2 or 3 feet in width, and they always have several openings.

During the growing season this species of ant is always to be found in attendance on various species of aphides or plant lice. During the summer of 1909 it was most commonly found together with the melon aphis (*Aphis gossypii* Glov.) on cucurbits, and with *Chaitophorus populicola* Thos. on cottonwood. The ants were also observed attending a species of Membracidæ on alfalfa, and late in the season after the leaves had fallen great numbers were found clustered and feeding upon crushed overripe cantaloupes, sometimes out in the field 25 yards from any ant nests.

As the ants were almost invariably to be found on aphis-infested cantaloupe vines, many of the growers are of the opinion that they are responsible, in part at least, for the spread of the aphides from one vine to another. There is also a rather general idea that the ants take the aphides into their nests in the fall, protect them throughout the winter, and then bring them out in the spring and put them upon the plants.

INJURIOUS HABITS.

There appears to be but little foundation for believing that the ants harbor the melon aphis during the winter, and after careful watching the writer has never seen any aphides being carried into the

nests. However, these ants do protect the aphides from their natural enemies on the growing plants, and it is a common thing to see the ants busily engaged in killing and carrying off the syrphid larvæ, which were doing good work in destroying the "lice." They were also repeatedly observed carrying away adults of the convergent lady-bird (*Hippodamia convergens* Guer.), the nabid bug *Reduviolus ferus* L., and a species of Chrysopa. The ladybird larvæ apparently were not molested, while the beneficial syrphid larvæ were objects of special attack, and it was not unusual to see as many as ten or twelve larvæ being carried away from a single vine at a time. Wherever the ants were abundant the syrphid larvæ were noticeably reduced in number, and the aphides thus had a better chance of increasing. The ants appear to use the syrphid larvæ as food, as they were observed carrying them into their nests, which, in several cases, were 12 or 15 feet from the vines infested by the aphides.

EXPERIMENTS WITH POTASSIUM CYANID AS A REMEDY.

As frequent inquiries were made by the melon growers concerning possible remedies for use against the ants it was decided to conduct a series of experiments. Owing to the large number of nests which occur along practically every fence and ditch, and to the large size of the nests, and particularly to the fact that each nest has several openings, it was obvious that carbon bisulphid would be too expensive for practical use with this species, and it was decided to make the experiments with various solutions of potassium cyanid. The object of these experiments was to determine if repeated applications would materially reduce the number of the ants and, if the ants were thus reduced, what effect it would have on the melon-aphis problem.

In making these experiments a strip about 80 yards in length was selected along a fence at the edge of a cantaloupe field. This strip was bordered along one side by a common road or highway and occupied along the center by a row of elm trees which were too small to cause any shade worth mentioning, as none of them was over 4 inches in diameter at the base. There were at least twenty-five distinct nests in this strip, and the ants occurred by thousands. Cantaloupes had been planted in the field along this strip for several successive years, and each year the first few rows nearest the fence were infested by melon "lice," while the vines which were beyond the convenient range of the ants were not infested, or at least not until later in the season. The owner of the cantaloupes was firmly convinced that the ants were responsible for the infestation of the first few rows and welcomed any attempt to destroy them.

In order to determine the cheapest and most practical solution the following preliminary tests were made:

Experiment No. 1.—One-half ounce of 98 per cent cyanid of potash dissolved in 1 gallon of water was used. On August 31, 1909, at 5 p. m., 2 gallons of this solution were applied to a nest 2½ feet in length by 2 feet in width. The entire outer surface of the nest was soaked and a considerable quantity was poured directly into the openings. Ants which were hit died almost at once and others which returned from the field and ran over the wet surface died within a few seconds. When the nest was examined an hour later the surface was well covered with dead specimens. There was still a fairly strong odor of the cyanid from the wet soil and returning ants were soon killed, although they did not die quite as rapidly as when the application was first made.

Experiment No. 2.—One ounce of 98 per cent cyanid in 1 gallon of water was used. On August 31, between 5.30 and 5.45 p. m., 4 gallons of this solution were applied to two nests, each about 3 feet long and 2 feet wide. The conditions were as in Experiment No. 1 and the immediate results appeared to be about the same.

Experiment No. 3.—Two ounces of 98 per cent cyanid in 1 gallon of water were used. On August 31, at 6 p. m., 2 gallons of this solution were applied to a nest about 3 feet long by 2 feet wide. The immediate results appeared to be about the same as in Experiments Nos. 1 and 2, although there was a somewhat stronger odor of the cyanid from the wet soil.

At the time these three tests were made the sun was warm and shining brightly. The ants were very active and thousands of them were away from the nests and among the aphis-infested cantaloupe vines.

Since the larger lumps of cyanid dissolved rather slowly some time was gained by breaking them up with a hammer.

At 4 p. m. on September 1 an examination was made of the nests treated in these tests. At that time there were hundreds of dead ants lying on the surface of the nests and a comparatively small number of specimens was running about. Most of the living ants had apparently lost interest in the aphides and had gathered on or about the treated nests and some were carrying dead specimens. There appeared to be little difference between the results of Experiments Nos. 1 and 2, but there were certainly fewer live ants about the nest treated in Experiment No. 3 than about the others.

As some fear was felt that a strong solution of the cyanid might kill the small elm trees which occupied the ant-infested strip and as Experiment No. 1 gave comparatively good results, it was concluded to continue the work with that strength. Accordingly, between 4.30 and 6 p. m. on September 1, the remainder of the infested strip, about 65 yards in length and containing 21 nests, was treated with

28 gallons of the solution at the rate of one-half ounce of 98 per cent cyanid to each gallon of water. At the time of this treatment there were thousands of ants either actually in attendance on the "lice" or running about between the nests and the infested cantaloupe vines.

At 6 p. m. on September 2 the treated strip was examined. Dead ants by thousands, at some places in heaps, were lying on or about the nests. Many dead specimens were also found out in the field from 6 to 10 feet from the nests. However, at every nest there were still a few live ants. Practically all of these survivors had gathered about the nests and it was difficult to find a live ant out in the field, where at the time of the treatment they occurred in surprisingly large numbers.

In order to test the effect of a second treatment applied soon after the first, two nests near the center of the strip were given a second application at 5.30 p. m. September 3. This was considered as Experiment No. 4. In this experiment 2 gallons of solution at the rate of one-half ounce cyanid to each gallon of water were applied to each nest as before.

An examination made of these nests on the following afternoon (September 4) showed that although a few additional ants had been killed no practical advantage had been gained by this treatment, and this conclusion was not altered by frequent later examinations.

Along the entire treated strip the ants which remained alive seemed demoralized for about a week, but by September 11 several small colonies had again started. The cyanid solution does not penetrate very deeply into the nests and it is evident that the pupæ escape destruction unless they are very close to the surface, and on reaching maturity they are able, with the remaining live ants, to reestablish the colonies.

By September 16 one or two of these colonies (nests) had reached fairly good size and although the ants were moderately common they occurred in very much smaller numbers than they did at the time of the first general treatment (September 2). This first treatment left the nests with a "crust" of compact soil over the surface. At two or three nests, just under the crust, the ants had large numbers of pupæ and at a few other nests a considerable number of winged adults had crawled out and was clustered about the openings.

At this date (September 16) all the nests in the entire strip were again treated with 25 gallons of the solution at the rate of one-half ounce of 98 per cent cyanid to each gallon of water. A particular effort was made to soak the winged specimens and the pupæ. All the adults touched were readily killed, but the pupæ showed no immediate effect from the treatment.

An examination made on the following afternoon showed that although the number of ants had been very considerably reduced

there were still some living specimens at each nest. The pupæ at the treated nests seemed to be dead and the living ants paid no attention to them. It was observed that at two places quite a number of pupæ had been overlooked and not soaked by the solution and at another place a moderate number of winged specimens had crawled from an opening of an untreated (overlooked) nest.

By September 27 about a dozen small, weak colonies had started, and on the following day between 4 and 5 p. m. all the inhabited nests were again treated with 25 gallons of the solution at the rate of one-half ounce of 98 per cent cyanid to each gallon of water. In this treatment all the openings in the nests were enlarged with a pointed stick and from a quart to a gallon of the solution poured into each. At this date many of the cantaloupe vines had been trampled down by the pickers or had died from disease or other cause. As a result there was not a very good supply of aphides in the immediate vicinity of the nests and the ants were mostly close about or in the nests. At two places many pupæ were present and at another nest there were a good many winged specimens.

Examination made on the following day (September 29) showed that there were still a few living ants about the nests, and the pupæ were still light in color and did not appear to be dead. A day later some of the pupæ appeared to be still alive, but as all of these were embedded in the moist soil, where the living ants paid no attention to them, they certainly could not have survived. At this time there was no odor of the cyanid over the nests, but when lumps of the moist soil were picked up the odor from them was quite apparent.

Repeated examinations made of the treated strip during October and November showed that the ants had almost completely disappeared, while at untreated (check) nests they occurred in large numbers. It would be interesting to know what became of the few specimens which survived the last treatment. Possibly they became discouraged and went to less troubled quarters.

It is evident that from experiments of this nature definite or final conclusions can not yet be reached. The work was begun so late in the season that the rather gradual decrease in the number of the ants had no marked effect on the melon aphis. It showed that to keep this species within reasonable bounds repeated applications of the cyanid and constant watching are necessary. As this would require so much more attention than the ordinary farmer can be induced to give, it does not seem probable that this method will ever become very popular for this particular species of ant, unless it can be definitely proved that this species is a more important factor in the melon-aphis problem than it is now known to be. It is very probable that quicker results would have been obtained if a stronger solution had been used.

At Rocky Ford, Colo., 98 per cent potassium cyanid was obtainable in small lots for 50 cents a pound. When used at the rate of a pound in 30 or 32 gallons of water this makes a comparatively cheap solution.

Although this solution is extremely poisonous, there need not be undue risk to human beings from its use if proper care is exercised in preparing and handling it. When leaning over a half barrel of the solution for the purpose of stirring it or dipping out pailfuls, the fumes were quite noticeable and, with the writer, caused a slight dull headache which lasted a short time. Although in applying the solution the writer's hands were frequently wet with it, and no ill effects resulted, yet it would be safer to keep the solution from coming into contact with the skin. Some persons are peculiarly susceptible to this poison, and with some its contact with the skin causes a rash. Persons with weak hearts should be especially careful not to inhale the fumes.

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L. O. HOWARD, Entomologist and Chief of Bureau.

SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE PECAN CIGAR CASE-BEARER.

BY

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Agent and Expert.

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SOME MISCELLANEOUS RESULTS OF THE WORK OF THE BUREAU OF ENTOMOLOGY—IX.

THE PECAN CIGAR CASE-BEARER.

(*Coleophora caryæfoliella* Clem.)

By H. M. Russell,
Agent and Expert.

INTRODUCTION.

Among the insects of minor importance that affect the pecan, the pecan cigar case-bearer (*Coleophora caryæfoliella* Clem.) is probably met with in groves more than any other species. At times the insect occurs in such numbers as to defoliate entire trees, checking their growth and considerably reducing the crop of nuts. In the future this insect is likely to cause increasing damage as the acreage in pecans increases, and it may become as great a pest to the pecan as *Coleophora fletcherella* Fernald is to the apple. The occurrence of this insect in large numbers at Orlando, Fla., during the spring of 1909 presented the opportunity of studying it, and the results are given in this article. The dates for appearance of the different stages are for that locality. These dates will undoubtedly vary as we go northward.

EARLY HISTORY.

Clemens[1a] first described this species in 1861, as *Coleophora caryæfoliella*, from larvæ found feeding in their cases on leaves of hickory during the fall. He gave a short description of the larva and case, but did not succeed in rearing the adult.

In 1872 Clemens's original description[2] was republished in his "Tineina of North America," edited by H. T. Stainton.

Chambers,[3] in 1874, described the adult under the name *Coleophora rufoluteella*, from specimens captured in Kentucky in June.

Writing again in 1878, Chambers[4] places his *rufoluteella* as a synonym under *caryæfoliella*. He wrote at that time: "*C. rufoluteella* Cham. is known only from captured specimens. I am, however, utterly unable to distinguish it from specimens bred by me in the latter part of June from larval cases found feeding on hickory leaves

[a] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 86.

in the manner described by Doctor Clemens for *caryæfoliella*, and I believe it to be the same species."

During 1882 Lord Walsingham[5] identified a specimen, reared from *Prunus americana*, as *C. rufoluteella* which he thought to be distinct from *caryæfoliella*. Packard,[6] in 1890, wrote of this insect, under insects injurious to hickory: "The larva feeds in a cylindrical case attached to the under surface of the leaves."

During the same year there was published in Insect Life[7] a brief note recording the parasite, *Rhyssalus trilineatus* Ashm., as having been reared from this species on hickory at Washington, D. C., May 5, 1893.

Apparently nothing more was written until 1905, when Gossard,[8] in his bulletin on pecan insects, mentions what is undoubtedly this species as "*Coleophora* sp."

RECENT RECORDS.

May 5, 1901, Mr. L. O. McPherson, of Josephine, Ala., sent in larvæ of this species affecting the pecan. Writing of this attack, October 23, 1905, Mr. McPherson stated that in the year mentioned this insect entirely denuded a number of large trees of their leaves during May and June only.

June 3, 1907, the larval cases of this insect were observed on pecan at Orlando, Fla. March 16, 1908, the winter cases of these larvæ were found clustered together on twigs of pecan in a deserted grove outside of Orlando. April 2 and 7, 1908, the larvæ were again observed at Orlando, Fla. They were just leaving their winter cases for the larger spring cases.

In 1909, during April and May, several large trees in the grove of Mr. C. W. Townsend, of Orlando, Fla., were almost completely prevented from putting out foliage until weeks after other trees had done so, because the larvæ of this species were so numerous on the buds and leaves. May 11 found this insect causing considerable defoliation to pecan trees at the old Standard Oil grove just west of Orlando, now owned by Mr. Long. At the same time it was abundant in all the groves around Orlando. On May 16 Mr. J. D. Mitchell, of this Bureau, reared this insect from leaves of pecan at Victoria, Tex.

DISTRIBUTION.

This species was first described by Clemens in a paper on North American Tineina, but the locality for his specimens is not given. V. T. Chambers records it from larval cases taken in Kentucky and records capture of the adult at Covington, Ky. Prof. H. A. Gossard records what is undoubtedly this species as met with on "almost every tree I examined for the purpose of finding it" in Florida. The author, while working in Florida during the years 1907–1909, found it in every grove examined around Orlando.

In the Bureau of Entomology and the U. S. National Museum there are specimens from McPherson, Ala.; Victoria, Tex.; Pittsburg, Pa.; Hampton, N. H.; Washington, D. C.; Virginia; and New York.

From these records of capture and injury, this insect seems to be distributed throughout the Austroriparian faunal area of the United States and may also extend into the Carolinian and into the lower edge of the Alleghanian areas.

FIG. 23.—Pecan twigs with buds and young leaves killed by pecan cigar case-bearer (*Coleophora caryæfoliella*). (Original.)

FOOD PLANTS.

The pecan cigar case-bearer feeds principally on nut-bearing trees, and of these it has been observed feeding on walnut, pecan, and hickory. It has been doubtfully recorded on dogwood and *Prunus americana*.

CHARACTER OF INJURY.

Damage by the pecan cigar case-bearer occurs during the early spring, principally to budded trees, and is due to the feeding of the larvæ on the tender buds and unfolding leaves. Where this insect is very abundant it causes injury in two ways. If the buds are backward in opening, the larvæ leave the twigs where they have hibernated, and crawling to the swelling buds attack them and eat out the contents, so that the life is destroyed, and before the tree can put out its foliage the dormant buds must develop. Figure 23, taken May 6, 1909, shows pecan twigs with buds destroyed by these larvæ;

the winter cases are still seen attached to sides of the buds. On the other hand, if the trees develop their foliage before the larvæ leave hibernation in injurious numbers, the leaves are riddled by the larvæ as they come from the twigs and the wind soon whips them to pieces. In this way, by feeding on the opening buds and young leaves in great numbers, this insect may delay the trees from coming into foliage for a period of from six to eight weeks. Because of this, young trees are held back during the most important period of their growth, and older trees, owing to this extra demand for nourishment for building leaves, probably have the crop of nuts for the year considerably decreased. Plate V, figure 1, shows a pecan twig with the young leaves ragged and largely destroyed by this insect, and Plate V, figure 2, shows the mines of the larvæ and some of the case-bearers at work. Plate VI is from a photograph of a pecan tree, taken May 6, 1909, showing injury by this insect. Plate VII shows a tree not attacked by this insect, which had been in full foliage for at least four weeks. When the writer left Orlando, June 13, the injured tree shown in Plate VI was still partly bare.

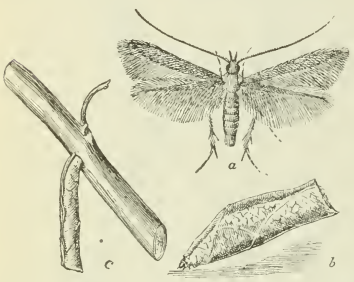

FIG. 24.—The pecan cigar case-bearer (*Coleophora caryæfoliella*): *a*, Adult; *b*, *c*, larvæ in cases. Greatly enlarged. (Original.)

DESCRIPTION.

The adult.—Coleophora caryæfoliella is one of the Microlepidoptera belonging to the family Elachistidæ, characterized by narrow, pointed wings with long fringes on the inner margins. The adult is a delicate little moth, ochreous in color, with a wing expanse of about 9 mm. The head is yellowish ochreous, with white scales over the eyes, the palpi and base of the antennæ the same color as the head, and the rest of the antennæ white ringed with brown. The body is the same color as the head, while the fore wings are reddish ochreous with costal margin white and fringe on inner border gray, and the hind wings are gray or whitish. This moth is well illustrated in figure 24 at *a*.

Chambers described the adult as follows:

> The species is ochreous; the head and palpi pale or yellowish ochreous; the antennæ white, annulate with brown; fore wings reddish ochreous, darker towards the apex, with the costal margin from base to cilia white.
>
> The ornamentation of the imago is nearer that of *C. limosipennella* than to any of the other species figured in *Nat. Hist. Tin.* Al. ex. 4½ lines.

The egg.—The egg has not been observed by the author, but is probably very similar to that of *C. fletcherella* as described by A. G. Hammar.[a]

[a] United States Dept. Agr., Bur. Ent., Bul. 80, Pt. II, p. 37, June 30, 1909.

Fig. 1.—Twig of pecan, showing injury to foliage. (Original.)

Fig. 2.—Leaves of pecan, showing mines. On upper leaf are larvæ in cases at work. About natural size. (Original.)

WORK OF THE PECAN CIGAR CASE-BEARER (COLEOPHORA CARYÆFOLIELLA).

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The larva and larval cases.—The case in which the larva passes the winter is small, 3–3.5 mm. long, very flat, cylinderlike, and by the end of winter has the same color as the twigs or bark on which it rests. In the spring the larva is found in a case that is considerably larger. This is 5–7 mm. long, cylindrical, flattened vertically at the upper end, and slightly rounded at the lower. This case is made from a hollowed portion of leaf and so shows the entire leaf structure. It becomes reddish brown in color, and resembles a minute cigar.

The mature larva is about 5.5 mm. long and 1 mm. wide, the cylindrical body having well-marked segments. The head is one-half as wide as the body, hemispherical, flattened, black in color, with the triangle reddish. The body is light brown, with cervical shield oval, shining black, divided along center by a light brown line. The third segment of the body has a small black shield like the cervical, the anal plate shining black. The surface of the body is finely punctured and bears scattered, short, white hairs. The legs are light brown, while the prolegs are wanting or very small, marked by minute elevations, except the anal pair, which are large and functional. The nearly mature larva is well illustrated in its case in figure 24, *b*, *c*.

The pupa.—The pupa is formed within the larval case, and is about 5.5 mm. long and 1 mm. wide, cylindrical, having nearly the same diameter throughout the entire length. The head and eyes are blackish, while the remainder of the pupa is light yellowish-brown. The leg cases extend beyond the tip of the abdomen.

Clemens described this species from the larval case, but did not rear the adult. His original description is as follows:

1. *C. caryæfoliella.* The larva mines the leaves of hickory in September and October. The head and body is [are] reddish-brown, somewhat darker on the second and third rings.

The case is small, dark brownish, and in form is a flattened simple cylinder. The larva feeds only in small rectangular patches, of which there are usually several in the same leaf. The case is fixed to the under surface and the larva feeds in one patch until it is compelled to remove its entire body from its case, and then removes to another part of the leaf to form a new mine.

HABITS OF THE ADULT.

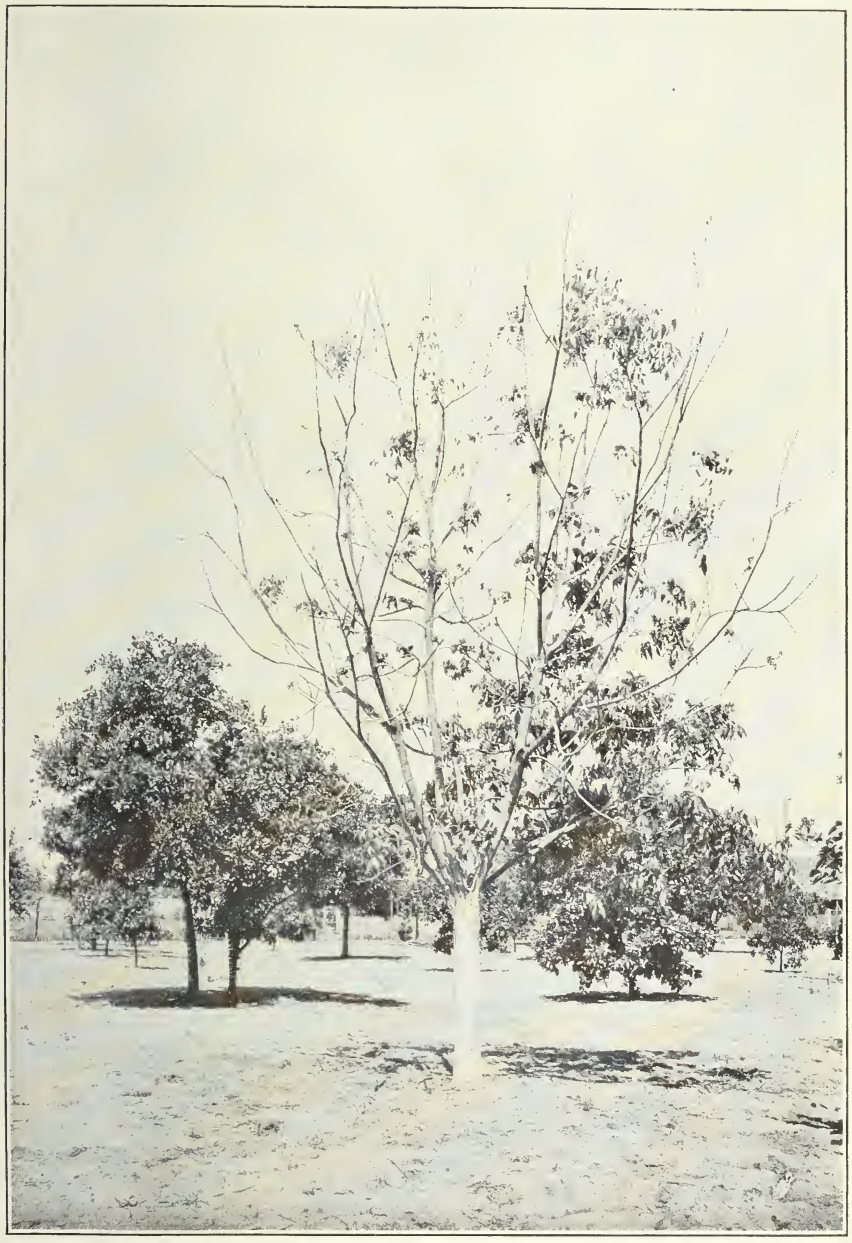
The moths emerge from the pupæ during May and June and at that time may be found among the pecan trees. When only recently emerged from the pupæ they rest either on the pupal cases or on the leaves or twigs of the host plant, with the fore wings folded back over the hind wings and flat over the abdomen, while the antennæ are held closely together and directed forward. During the day they seem to rest among the leaves.

HABITS OF THE LARVA.

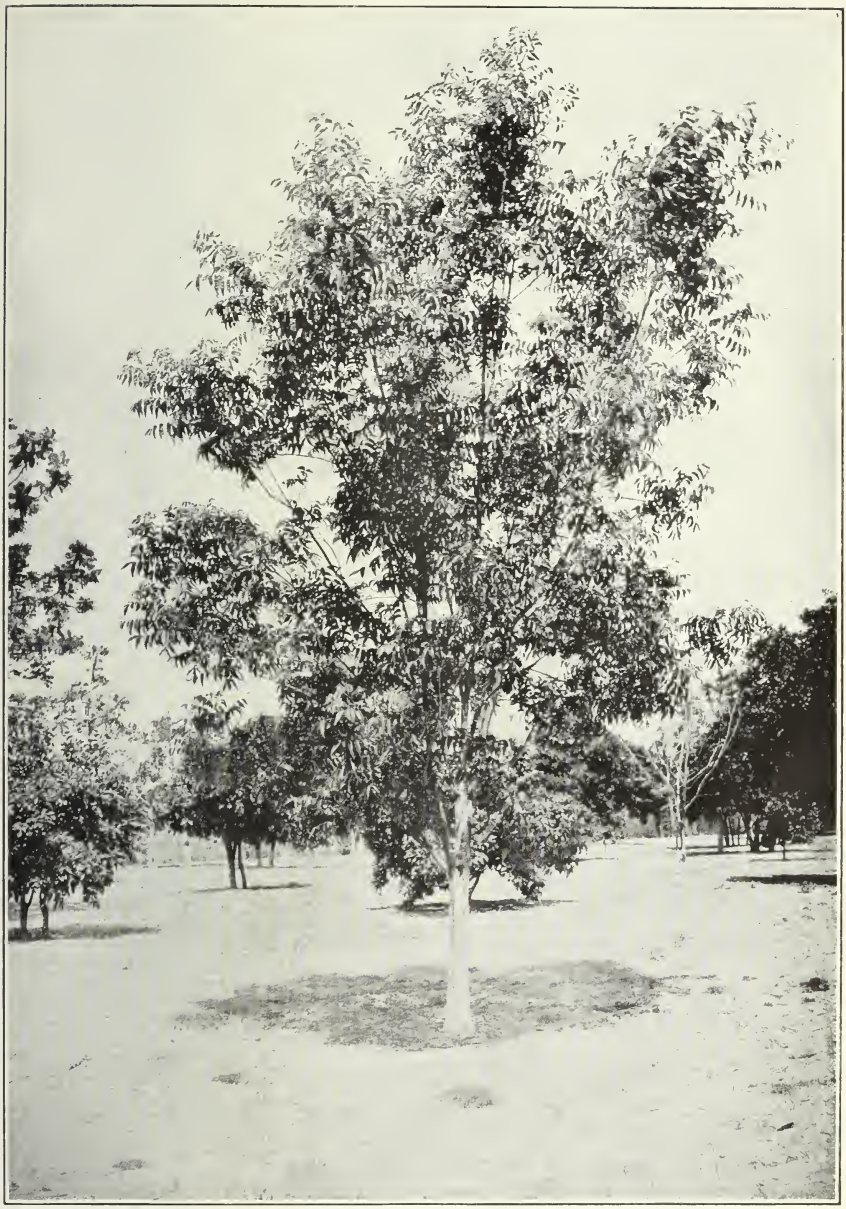
The larvæ of *Coleophora caryæfoliella*, upon hatching from the eggs in July, mine the leaves of the host plant, and after feeding there for some time cut out the two skins of the mine and construct the cases within which they live during the fall and winter. After the cases are made the larvæ feed upon the leaves by eating through the lower epidermis and tunneling out the interior of the leaf in all directions until the mine is so large that to mine farther the larvæ would have to leave their cases. Under such conditions they move and begin a new mine, so that the leaves become full of irregular rectangular patches of brown with a small round hole in the center on the underside. In feeding, the larvæ carry the cases nearly perpendicular to the leaf surface. When the larvæ move they extend the head and thorax and crawl along, bearing the case aloft behind. In the fall, some time in October, before the leaves fall, these larvæ move from the leaves to the twigs or to the trunk, where they get behind the bark. Often they get in between the bud and the twig. Here they fasten the cases to the support and hibernate. The writer has seen from fifteen to twenty minute cases on a twig 4 to 5 inches in length, and where very abundant they will cluster together literally in hundreds. Gossard[7] has a photograph of these winter cases completely covering a twig.

In the spring, when the weather becomes warm enough, generally between March 15 and April 1, these larvæ become active and leave the twigs, where they have spent the winter, to commence feeding. If the trees are backward they often begin to feed before the leaves have developed and in such cases attach themselves to the swelling buds. Each larva eats a minute round hole into a bud and feeds as long as it can reach food without leaving its small case. When this becomes impossible the larva changes position and attacks the bud in a new place, so that infested buds are often found with four or five holes in the sides. Under such treatment the buds are killed or the tiny leaves start and are killed, and turning brown drop off. Often the larvæ attack the young tender leaves and mine out rectangular blotches in them. About the first week in April these larvæ outgrow their winter cases and construct larger ones.

Larvæ forming new cases move to the edge of the leaf and mine between the two skins. They then cut out a portion of the leaf, using the edge for one side. The sides are then sealed with silk, an opening being left at one end for the head. From the method of making new nests one edge of the case will often show serrations of the leaf edge. The larvæ then leave the old case attached to the leaf, where the latter has been cut to form a new case. They eat out large mines from 2 to 8 mm. long and 4 to 5 mm. wide (Pl. V,



PECAN TREE, SHOWING FOLIAGE CHECKED AND INJURY BY PECAN CIGAR CASE-BEARER.
(ORIGINAL.)



NORMAL PECAN TREE, SAME SIZE AS THAT SHOWN IN PLATE VI, BUT WITHOUT INJURY BY THE PECAN CIGAR CASE-BEARER. (ORIGINAL.)

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fig. 2) in the leaves, feeding generally on the under side but sometimes on the upper also. These mines are deserted by the larvæ when they can not reach more of the surrounding tissue without leaving their cases, and new mines are made. In this way badly infested leaves may have from six to twenty mines to each leaflet. Soon the old mines dry up and are broken out by the wind, leaving the leaves full of ragged holes. The larvæ feed during the day and can often be seen with the head and part of the body inserted between the leaf surfaces, eating out the tissues in an ever-enlarging angular mine. If disturbed or in search of fresh food, these larvæ will move around considerably. When making a new mine the end of the case is loosely fastened and held diagonally attached, to the leaf. (See fig. 24.)

HABITS OF THE PUPATING LARVA.

During May most of the larvæ become mature and they then either fasten the case tightly to the leaves and pupate or move to twigs, branches, or bits of bark on the trunk of the tree and fasten the cases there. The larvæ spin a quantity of silk by which they fasten the cases very firmly to the support, after which they reverse their position, so that the head is pointing out toward the unattached end. After remaining quiet for a number of days the pupæ are formed, and the adults emerge during the last of May or the first of June.

SEASONAL HISTORY.

As far as observed, this insect has only one brood during the year, the larvæ hibernating when only partially grown.

In Florida the larvæ of this species become active from the 15th to the 30th of March, when the buds of the pecan are opening, or just after they have opened. Leaving the twigs and sheltered places where they have hibernated, they begin feeding on the buds or tender leaves. In a short time these larvæ outgrow their old winter cases and construct new ones of larger size. During the spring of 1908 this occurred mostly between April 1 and April 7.

The larvæ, after forming new cases, continue feeding and grow rapidly until May, when they become full grown.

By May 4, 1909, a few larvæ pupated and, as others pupated from time to time, by May 19 or 20 the greater part of the brood was in the pupal state. This pupal period occupies about twelve days.

An adult was observed in the cage on May 11, but most of the moths emerge from May 27 to June 5. On June 3 the adults were abundant on the foliage of pecan.

The adult probably lays her eggs on the underside of the leaves during June, and by the middle of July the larvæ are working as miners in the leaves of pecan. After a time they construct their

minute cases and feed on the foliage until fall, probably until the last of September or first part of October, when they move to twigs to hibernate, sometimes being packed around them by the hundreds. Others hibernate under bits of bark on the trees or in crotches and other sheltered spots.

RECOMMENDATIONS.

Where this insect becomes abundant enough to be injurious it can with little doubt be controlled by spraying the trees with arsenate of lead (at the rate of 3 pounds to 50 gallons of water) when the buds are swelling—in March in central Florida and in similar climates. When the larvæ attack the foliage, this should be similarly sprayed.

Lime-sulphur mixture applied during the dormant season would undoubtedly give good results.

Where trees are sprayed in spring for the budworm (*Proteopteryx deludana* Clem.) no further treatment will be required for the case-bearer.

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